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SPHERE-GAPS

THE measurement of different types of test voltage sometimes poses technical problems, and an accurate solution is often expensive or limited in its application. The sphere-gap is one means of measuring peak voltage, for which the results with alternating, impulse or direct voltage are substantially the same. The measurement involves the spark breakdown of the air in the gap, which then short-circuits the output of the voltage source. In many cases, this short-circuiting can be tolerated, or its disadvantages are outweighed by the simplicity of the sphere-gap.

This month's cover illustration shows the upper unit of three cascade-connected power-frequency test transformers which produce 1 MV, a 2·8 MV impulse generator, a sphere-gap for voltage measurement and protection, and an observation gallery in the background. The 100 cm spheres are suitable for use up to 1000 kV (peak), with a voltage-measurement accuracy within ±3–5%. Some of the factors that influence this accuracy are reviewed in an article 'Breakdown voltage of sphere-gaps in air' by Dr. E. Kuffel and Mr. A. S. Husbands on p. 372

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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ENGINEER FOR THE COMMONWEALTH

THREE key sentences in The Duke of Edinburgh's Graham Clark Lecture (published in full on p. 340) throw new light on the task of the engineer and give it a wider significance in relation to the peaceful progress of the world. He said:

'In this lecture I have tried to show that the engineer is the key figure in the material progress of the world. This is particularly important at this moment in history when we are beginning to realize the dangers in a situation where some countries are enjoying all the fruits of material progress and others none at all. There is a growing feeling that this unbalance is neither morally acceptable nor is it likely to improve the chances of peaceful conditions.'

Most engineers, when they ponder the nature and significance of their vocation, are driven to accept the assumption that material progress is objectively a good thing. Lingering doubts tend to remain when they look at the way material progress is sometimes used, by individuals and by nations. But such doubts disappear when material progress is conjoined with the objects of world peace and co-operation. These objects, all would agree, are inherently good and proper for a man to strive for.

So, if a condition of world peace and friendly co-operation is the sincere stretching out of the hand of material progress by the advanced industrial nations—and who can doubt it?—the engineer has inherited a peace-making role in the second half of the 20th century. He can be helping to lay the foundations of world peace and progress while others are still busy with the paper plans.

This is a large idea, but how do we translate it into practical concepts? Prince Philip gave a lead in this also. He concentrated on the Commonwealth, that world community of lands and races that is distinguished from some others by the fact that, contrary to recurring prediction, it works. It is the engineer for the Commonwealth who, if our assumptions are correct, will make it continue to work, and make it work ever more efficiently.

But it is certainly a comfort to have some specific object like the Commonwealth on which to concentrate our gaze. The world is too large, too vague a concept for most of us. Not that the Commonwealth is a small pond. It is quite big enough to provide far more opportunities than the engineer can ever hope to take. It embraces 23% of the world land area and 24% of the population. Commonwealth engineers might be forgiven for feeling that they had done their duty when they fixed their minds on Commonwealth development and left the rest of the world to look after development elsewhere.

The problems of the underdeveloped countries of the Commonwealth are immense, but so are the material resources available. Let us look at one or two of the mineral reserves. Canada has over 500 million tons of petroleum, Australia at least 720 million tons of iron ore, New Zealand more than 1000 million tons of coal, India 50 million tons of ilmenite, Pakistan about 5 million million ft^3 of natural gas, Malaya 1·5 million tons of tin, Northern Rhodesia 24 million tons of copper, Uganda over 200 million tons of phosphates, Jamaica 500–600 million tons of bauxite.

The nations' natural resources are, as Prince Philip mentioned, 'at the root of all development; they are the raw materials with which engineers have to work in order to fill the basic needs of the peoples of the world'.

Machines are also available, and a reasonably good effort is being made to extend and encourage credit to the underdeveloped countries of the Commonwealth to enable them to purchase plant and equipment.

It is the human resources that are the problem. 'It is quite useless', said the Duke, 'for the more fortunate countries to offer their help in building dams, power stations and factories if the managers and engineers needed to operate them are not available. Furthermore it doesn't take very long to put up the physical structures but it may take anything up to 15 years for the people to gain sufficient knowledge and experience to run them.'

The countries concerned are very conscious that technical education of the highest quality must be supplied in staggering quantity if the gap in material standards between themselves and the luckier countries is even to remain as it is, let alone be reduced. To do so, they must leap-frog the whole period of the Industrial Revolution, when the people of the industrialized nations were learning, by bitter trial and error, how to organize an industrial society and were acquiring the skills that now provide the solid basis for technological advance.

Unaided, this colossal task must be too great for the underdeveloped countries, with their populations just emerging from a largely static agricultural economy. Aid on a scale hitherto undreamed of must be forthcoming if peaceful progress is to continue in the world.

Prince Philip stated the need thus: 'Colleges, equipment and teachers are all badly needed and teachers in particular will be needed for a great many years to come. This means that those countries with well-established higher technical educational facilities must take this added responsibility into consideration. Providing places for other Commonwealth citizens is only a temporary emergency solution; in the long run engineers and technicians must have their basic training in their own countries'.

A notable example in this regard is the Delhi College of Engineering and Technology, the foundation-stone of which was laid by Prince Philip in January 1959. Government and industry in Britain have agreed to provide professorial staff and equipment. This is an example to be emulated and multiplied, wherever the need is greatest. Let us hope that this kind of friendly co-operation will spread increasingly throughout the Commonwealth. Not that the aid will all be one-way: as the Duke pointed out, 'Canada has already gained considerable experience in hydroelectric work. India and Pakistan are deeply involved in irrigation problems. New Zealand is very advanced in dairy technology . . .'.

It is teachers of engineering, therefore, that are required in the Commonwealth. But not only teachers in educational establishments. In the university of industry every engineer is a teacher. The industrialized countries recognize this in the way they integrate college and industrial training. The complete engineer is a product of a combined effort by educational establishments and industry. There is thus a crying need for a two-pronged programme of training aid by engineers in teaching and in industry, working and teaching in the underdeveloped countries.

A Minister said in the House of Commons the other day that there was a need for professional people to regard it as natural to spend part of their working lives abroad. We support his view, and his hope that an increasing number of firms, public and private, would recognize the need.

The founders of the Commonwealth were traders, missionaries, explorers. They were followed by administrators, soldiers, doctors and some engineers. Now the call is for engineers, teachers and managers. The engineer for the Commonwealth does not stop his ears to the call. His task is to give 'direction and purpose to the progress of the world' and to introduce 'the fruits of modern science and engineering to the best advantage of the people'. The engineer for the Commonwealth can do this for one-quarter of the population of the world, and he accepts that he carries the main responsibility for reaching the target of a reasonable material standard for all the peoples of the Commonwealth, and thereby to further progress and peace.

WORK OF THE NATIONAL PHYSICAL LABORATORY

THE report for 1960 of the National Physical Laboratory*, Teddington, Middlesex, contains the Executive Committee's report and deals with administrative matters of general interest and the work of the various divisions of the Laboratory.

The Executive Committee's report shows that two new proposals arose in 1960. The first was for research on very-high-speed digital computers; the second was for a nuclear reactor for standardization work in nuclear physics. The feasibility of producing an electron microscope operating at 1 MV was considered.

In the Applied Physics Division, work was started on the use of bridge methods for the determination of losses in transformer-core material. A transistorized sensitive magnetometer was produced in portable form, capable of measuring fields as low as 10^{-4} oe.

The Autonomics Division continued the development of the planar cryotron, a computing component using the effect of superconductivity at liquid-helium temperatures. Planar cryotrons with a current gain of $2\frac{1}{2}$ were made and tested singly in d.c. conditions. Work was carried out on the automatic recognition of numerical characters. The automatic computing engine (ACE) was developed to the stage of a fully working computer.

The caesium resonator in the Standards Division continued to serve as the national standard of frequency and time-interval, with an accuracy within 1 part in 10^{11}. The original model was supplemented in 1959. Good progress was made on the construction of a new Campbell-type mutual inductor with improved precision.

* NATIONAL PHYSICAL LABORATORY: 'Report for the year 1960' (H.M.S.O., 1961)

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Propeller phase-synchronizing system

Which airline passenger has not been jarred and shaken to the teeth by aircraft din and vibration? This article describes an attack on this problem: an electromechanical servo-system that provides true propeller phase-synchronizing and consequently perfect speed-synchronizing. It is based on the author's Chairman's Address to the North-Western Electronics and Communications Group of The Institution. Mr. Heys is with the De Havilland Aircraft Co. Ltd.

C. HEYS, MEMBER

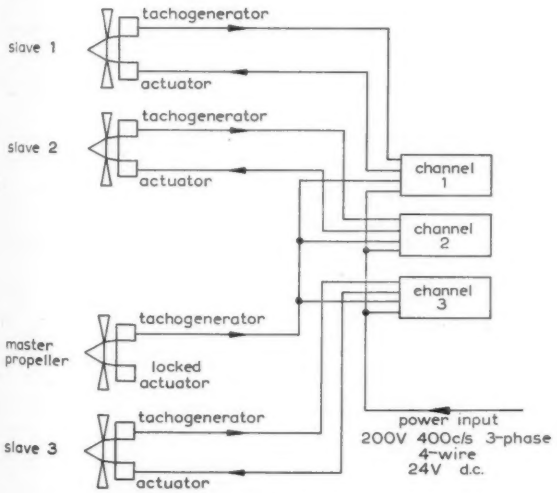
PROPELLER phase-synchronizing greatly reduces noise and vibration in the aircraft cabin and structure, thus improving passenger comfort and increasing the effective aircraft life, which is governed in part by the vibration set up by the propellers on large turboprop aeroplanes.

Basic aircraft system

Phase-synchronizing means that the angle between the two propellers is controlled: one propeller is the master and the controllable one the slave. One computer or channel is required for each slave propeller; in a four-engine aircraft, there are thus three channels. The computer measures the relative phase difference between a slave and its master and, by means of the trimming actuator, alters the reference point on the constant-speed unit fitted to the slave propeller. This alters the propeller speed slightly, thus advancing or retarding the phase relationship between the two propellers to the particular angle previously set up on the computer.

A trimming actuator is fitted to each constant-speed unit, but that on the master constant-speed unit is locked in its mid-position. The trimming actuator has only a limited control of the constant-speed unit, and so the propellers must be roughly synchronized, say to within 50r.p.m., before the electrical system is switched on.

Fig. 1 shows the basic system for a four-engine aircraft.



1 *Basic system for a four-engine aircraft*

Basic computer loop

On each propeller a 3-phase tachogenerator is fitted, running at four times the propeller speed. The two signals are fed into the computer and then to the differential synchronous motor or 'mono-diff.'. The angular position of its shaft is the algebraic difference between the angular positions of the shafts of the two tachogenerators; it thus senses the phase difference between the two propellers.

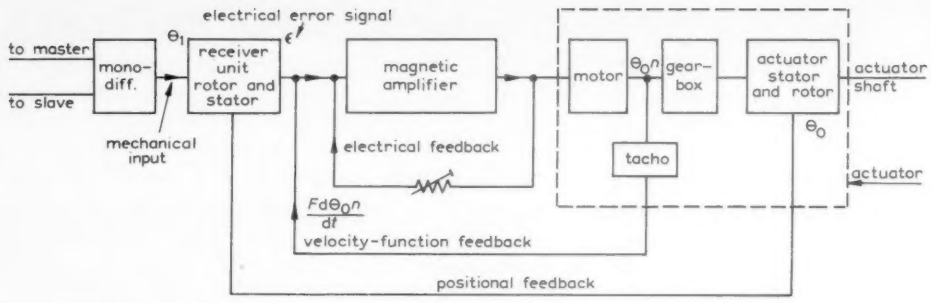
If there is a speed difference, the mono-diff. rotates at the difference speed. Stops in the computer restrict the angular travel so that, if there is a speed difference, the mono-diff. rotates and takes up a position on one of the stops corresponding to either high or low speed. If the speeds are identical, the mono-diff. takes up a position proportional to the phase differential. Fig. 2 shows the basic amplifier loop.

The receiver and the actuator are synchronous control transformers, made up of slab-type rotors and stators. They produce an error signal dependent on the angular difference between the receiver and the actuator. The a.c. error signal is of varying voltage and phase, the phase depending on the error direction. The error signal is amplified in the magnetic-amplifier circuit, and the output is fed to an a.c. motor that turns the actuator shaft in the direction that removes the angular error that produced the error signal.

Feedback

The feedback for the basic loop takes two forms:

1. Electrical feedback to stabilize the amplifier circuit
2. Velocity-function feedback from the tachogenerator attached to the a.c. motor in the actuator, thus providing basic-loop feedback to stabilize the servomechanism.



2 *Basic amplifier loop*

As in all servo-systems, the velocity-function feedback governs the stability of the system, and hence tolerance in components must be taken into consideration. This is done by altering the electrical feedback and so varying the effective gain in the amplifier.

The basic equation for the servo loop is:

$$I\frac{d^2\theta_o}{dt^2} + F\frac{d\theta_o}{dt} + K\theta_o = C\theta_i \quad . \quad . \quad . \quad . \quad (1)$$

where I is the moment of inertia of the system, F is the constant for the velocity generator, K is the constant for the amplifier-gain and gear ratios, θ_i is the phase-error-angle input, θ_o is the actuator output, and C is the electrical constant of the synchro-control transformers.

The general form of solution for eqn. (1) depends on the factor $\sqrt{(F^2-4IK)}$, which governs the system's stability.

For a stable system, F^2 must be either equal to or greater than $4IK$; thus we can equate F^2 to $4IK$. As I is fixed, F^2 is proportional to K. Thus, if F varies, K must be made to vary also, which is done by adjusting the amplifier gain.

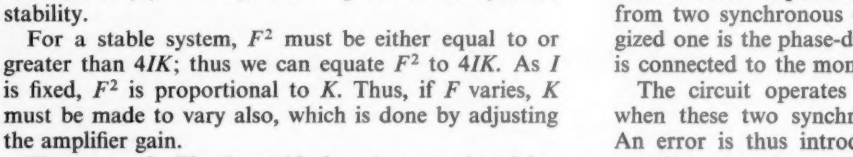
The system in Fig. 2 would give phase-synchronizing but it would be fixed, so these refinements are necessary to make the system practical:

1. Manual control of phase datum
2. A circuit to govern the amount of gain at different sectors of the actuator travel. This prevents the actuator from hitting its stops and reduces the risk of damage to component parts.

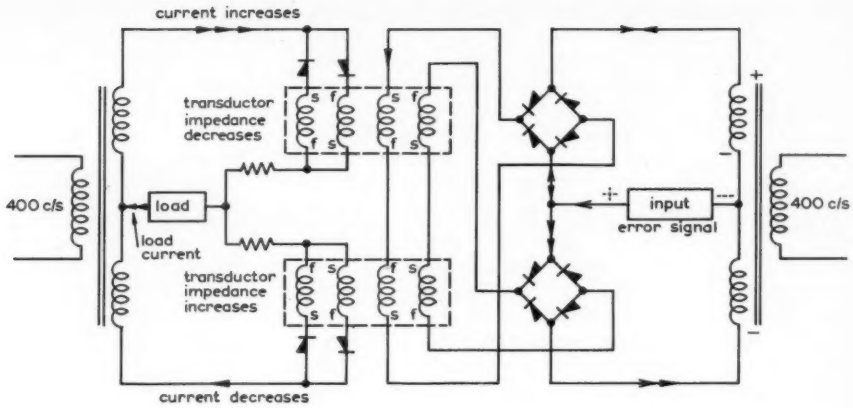
Phase-datum loop

The basic error-circuit starts with the receiver rotor, the error depending on the relative position of the actuator and receiver. If, however, the receiver stator is rotated around the rotor, an error is produced in the main loop which alters the propeller speed and tends to reduce the original error. The stator is rotated very slowly by a small integrating motor. The motor is driven by a magnetic-amplifier circuit similar to the main amplifier but with less amplification. The error signal is derived from two synchronous control transformers: the energized one is the phase-datum control, while the receiver is connected to the mono-diff. gear change.

The circuit operates on the error signal generated when these two synchros are electrically unbalanced. An error is thus introduced into the main positional amplifier when the receiver stator is rotated, altering the propeller speed and so the phase. This continues until the slave and master propellers are phase-synchronized.



3 *Magnetic-amplifier circuit*
a balanced



3 *Magnetic-amplifier circuit*
b unbalanced

Two other minor circuits are introduced, one to improve the transient response and the other to prevent mechanical damage to the actuator. These are connected together so that, when the actuator approaches its limits, the velocity-chop amplifier biases off the phase-error rate-of-change amplifier, reducing its gain and the transient response of the system.

Self-centring system

It is necessary to centralize all actuators when phase-synchronizing is not required, e.g. when the aircraft is taking off or landing. When the d.c. supply to the computer is switched off, the receiver rotor is switched out of circuit and the signal from the actuator fed directly into the error circuit of the main positional loop. The signal from the actuator is at zero when the actuator reaches its central null position. The actuator thus moves towards the centre under the influence of its own error signal and comes to rest at centre.

Basic magnetic-amplifier circuit

Fig. 3a shows the basic principles of the magnetic-amplifier circuit.

The circuit in Fig. 3b is used with refinements in both the main positional-loop amplifier and the integrating-motor amplifier. It is also used in the phase-error rate-of-change amplifier, but in this application it is preceded by a differentiating network and its output is fed into the error circuit of the main positional amplifier.

Acknowledgments

The author is most indebted to the Technical Director, Chief Engineer and Project Engineer of the De Havilland Aircraft Company for their valuable assistance and permission for this article to be published.

Summary

The system is designed to synchronize the number of revolutions per minute of the slave engines if they are set to within ± 150 r.p.m. of the master engine, and to maintain propeller-blade phase error within $\pm 8°$ in normal operating conditions.

This installation has been adapted to the *Tyne* engine and will go into service in the Vanguard with British European Airways some time in 1961 and with Trans-Canada Air Lines shortly afterwards.

EXPORTS TO CANADA

GREATER efficiency and better service to United Kingdom manufacturers (and possibly some reduction in over-all costs to British industry) should result from changes made recently in the organization of the British Standards Institution/Canadian Standards Association Agency.

In 1949, the B.S.I. sent a mission to Canada to discuss with the C.S.A. arrangements to obtain approval of British manufacturers' equipment prior to its being shipped from the United Kingdom. The system operated by the C.S.A. is probably the most stringent set of requirements in any country and acted as a serious barrier to British exports in the years after the Second World War.

Results

The negotiations in 1949 resulted in the setting up of the B.S.I./C.S.A. Agency in January 1950, which enabled manufacturers to obtain the necessary advice on, and approval of, all types of electrical equipment. In the ensuing years, all administrative difficulties have been completely resolved, and the Agency provides approval and consultative services not only concerning the electrical approvals system but also concerning similar services in respect of boiler and pressure vessels and welded fabrications.

Another important feature of the Canadian approvals system is the follow-up inspection, put in operation after approval is released to manufacturers, which includes periodical visits to licensees' factories to ensure that requirements are maintained. Canadian manufacturers are becoming increasingly interested in the United Kingdom market, and a start has been made to provide them with the same kind of approval service as their British counterparts have been receiving.

*The Seventh Graham Clark Lecture**

THE ENGINEER IN COMMONWEALTH DEVELOPMENT

H.R.H. THE PRINCE PHILIP, DUKE OF EDINBURGH, K.G., F.R.S., HONORARY MEMBER

INTRODUCTION

THE first thing I did, before preparing this lecture, was to look up all the previous Graham Clark Lectures. As it was I accepted your invitation with great diffidence but when I saw who had been my predecessors and what they had said—my heart sank. I realize it is meant as a great compliment, but if you only knew what a lot of hard work I had to do in preparing it I'm sure you would have thought of some other way of paying me a compliment.

Mind you I'm not complaining. This task has proved to be a very important and worthwhile stage in my education so I am most grateful to The Institutions of Civil, Mechanical and Electrical Engineers for inviting me to give this 7th Graham Clark Lecture.

I cannot hope to condense into this one lecture the whole story of engineering in Commonwealth development, but I shall try to get across some of the results of fairly extensive travelling and research. I must confess that I am very bad at statistics so I have tried to avoid them in the text, but those who like them will find that the Appendices contain several interesting and, I hope, illuminating tables to do with Commonwealth resources and development.

Some of you may have seen that the original title was 'Resources, human and material, of the Commonwealth'. However, I very soon came to the conclusion that resources are not very interesting until you start doing things to them and that engineers are probably the biggest—if not the most important—group of people who do things to resources. So I changed the name and I have tried to outline the engineer's part in the various fields of development and some of the opportunities and problems of your profession.

I wrote most of this lecture at odd moments during our recent tour of India and Pakistan. Not perhaps an ideal way to set about it, but it did have the advantage that I was able to look at things from the point of view of the relatively less developed countries. You are now about to experience the disadvantages of composing a lecture under these conditions and I can only apologize if you find it a bit disjointed.

I am going to take it for granted that it is generally accepted that development in the broadest sense is a good thing. I hope I can assume that mankind is better off with proper food, sanitation, housing and all the material comforts which modern science, engineering and industry can provide. I am not assuming, however, that this material development necessarily implies a higher standard of human civilization. This, I believe, depends upon qualities of the mind and spirit which are not directly related to material comfort and convenience.

Given the need for development in the material sense it does not take a great stretch of the imagination to visualize the engineer's part in the process. There are, in particular, four ways in which the engineer can implement and influence development:

1. By continually finding practical ways and means of applying scientific principles and discoveries in power, industry, transportation, communication and construction. This means that research establishments are needed in all the divisions of engineering so that practising engineers can apply the benefits of fundamental scientific research
2. By the application of the latest and most efficient methods to individual projects. This means that practising engineers must have some way of keeping up to date
3. By the careful administration, maintenance and improvement of the engineering complex. Building or developing some project from scratch may have a great many difficulties, but maintaining and improving a project which has been in existence for many years calls for even more skill and administrative ability. Railways are an obvious example

* The Lecture was delivered at a Joint Meeting of The Institutions of Civil, Mechanical and Electrical Engineers in the Great Hall of The Institution of Civil Engineers, Great George Street, London, on the 13th April 1961

4. By the technical training and education of the next generation of engineers. This is very much the engineer's responsibility and whatever the rewards of practice may be, nothing is more worth while in the long run than teaching the next generation.

The Duke of Edinburgh delivering the Seventh Graham Clark Lecture on the 13th April 1961

The engineer is in fact the means by which the people are able to enjoy the fruits of science, whether in building new projects, or in maintaining and keeping up to date what is already in existence. I need hardly list the highly developed communities of history which decayed for the lack of engineers to keep their great works in operation.

Simple technical know-how is also not enough. In order to make a really worthwhile contribution the engineer needs the vision to appreciate what is possible as well as the technique to realize his dream.

It is also wrong to assume that the engineer is simply concerned with material gadgetry or the purely practical and commercial side of life. All large-scale projects and modernization plans are bound to have a profound and lasting influence upon the lives of very great numbers of people. Unless their conception, execution and running are all based upon a practical humanity they will contribute very little to man's progress.

That is why technological training must be combined with a broad general education. Each generation must learn that technical knowledge without a sense of mission and responsibility is wasted. Education which merely produces a sense of dissatisfaction and frustration and a kind of topsy-turvy snobbery about what is suitable and unsuitable employment is a failure. The system must instil a sense of the value of engineering to human development so that people come to look upon it with the same sense of service as missionaries and doctors.

At the root of all development are the nations' natural resources; they are the raw materials with which engineers have to work in order to fill the basic needs of the peoples of the world. Food depends on agriculture and increased agricultural productivity depends on agricultural machinery, irrigation, food processing and transport. Industry depends upon power and upon the extraction and transport of its raw materials. Industrial processing itself depends upon the engineer as does the invention and design of those gadgets which are intended to help or entertain the public at large. On top of that lies the very important responsibility of teaching the next generation of engineers in such a way that they can progress from past techniques and build on past experience.

The wealth of a nation, and all which that implies, depends in fact upon the efficient organization of its resources both natural and industrial as well as human. In this organization the engineer bears the chief responsibility.

FOOD AND AGRICULTURE

The engineer has two kinds of resources with which to work. There are the renewable resources, by which I mean those which grow or which are renewed by the climate, and non-renewable resources, those which are extracted once and for all.

Luckily in supplying humanity's basic need of adequate food the resources are not only renewable but the area which can grow them, as well as the quantity from a given area, can be substantially increased by modern engineering and scientific methods. This is particularly fortunate because no country can hope to reap the benefits of industrialization without a sufficient and cheap supply of food for both the rural and urban population. Secondly, if the world's food resources had a known limit at this time the tremendous increase in the population of the world would pose an insoluble problem. As it is things are difficult enough. Dr. Norman Wright of the F.A.O. estimates that the world population will have grown from 3000 million today to 4000 million in 1980 and 6000 million in 2000. On the basis of bringing the average world diet to a reasonable level by 1980 he suggests that we must increase the world's cereal production by 33% and the world's production of milk, meat, eggs and fish by not less than 100%. By the year 2000, which is only 39 years away, the figures are a 100% increase for cereals and 200% for animal products.

Dr. Wright bases these figures on a broad estimate that the food supplies of countries representing 60% of the world's population fall below 2200 calories per day of which nearly half are below 2000—a figure which is 800 calories less than that at which British adults and children start to lose weight.

This situation is even worse than it sounds because in most underdeveloped countries there are inadequacies in quality as well as quantity of food, with the result that the people suffer from malnutrition as well as undernutrition. In North America for instance only 25% of the diet is in starchy foods while in Africa it is 66% and in the Far East it rises to 73%.

I promised not to bring in too many statistics, but there are one or two more which I am sure you will find revealing. The Commonwealth fraction of the world land area is 23% and the fraction of the world population is 24%. Even though Britain has the highest population density, 68% of the Commonwealth population is in India and Pakistan. Out of a total Commonwealth population of 682 million no less than 56% are employed in agriculture—5% of Britain's, 12% of Australia's and 71% of India's. The really interesting part of that comparison is that agriculture, forestry and fishing employ 5% and are worth 4% of the gross domestic product in Britain. Australia employs 12% which produce 17%, whereas in India 71% of the population only produce 47% of the gross domestic product. This shows very clearly that great strides are possible in agricultural productivity.

For these and most of the statistics in the Appendices I am greatly indebted to the Commonwealth Economic Committee and to the Commonwealth High Commissioners' offices in London.

I said just now that for the time being we are also fortunate that the land area for agriculture can be increased. In fact 44% of the Commonwealth land area is either unused, built-on or wasteland. This figure needs to be qualified, however, because one-fifth of the undeveloped land surface is too cold, one-fifth too arid, one-fifth is mountains and one-tenth has no soil. This leaves about 30% as potentially cultivable and gives some idea of the scope for bringing deserts, equatorial forests and tropical grasslands into production, and the tremendous contribution which engineering can make to agriculture.

Four things are needed to stimulate and increase agricultural productivity:

1. Extension of the area under cultivation which generally means the provision of water in dry areas, the removal of water in swampy areas, and the control of pests, diseases and weeds
2. Increasing the productivity of the soil by applying more nutrients. This is the first impact of industry proper upon agriculture because plants need fixed nitrogen, phosphorus and potassium which have to go through some sort of industrial process before they are usable
3. Better equipment for use on the land so that together with the increased use of fertilizers the output per acre can be substantially improved. In the industrially developed countries very sophisticated machinery is needed to increase the output per man. In the less developed countries the emphasis should be on improved design of simple instruments. Remember the ground-nut scheme which prompted the remark 'Give us the job and we will finish the tools'
4. A system of agricultural organization which will make it worth while for the rural population to grow food for sale. This includes the organization of land tenure, proper transport and marketing facilities and a comprehensive advisory service.

It is no use attempting any or all of these things without taking human nature into account. These points may be self-evident to an outsider but you cannot, without much suffering, force human nature to accept a complete change—even for the better—of the basis of its existence overnight. The art in this case is to reconcile the interests of the individual with the interests of the State.

Much progress has already been made and if we learn from the successes even more rapid progress is possible in the future.

It is only necessary to look at the tremendously high agricultural productivity of New Zealand to realize what can be done under very favourable conditions. The Gezira cotton scheme in the Sudan is an excellent example of all the points I mentioned, while the huge irrigation schemes in India and Pakistan are both an encouragement and a warning. Warning because the early schemes have given rise to waterlogging and salinity which are taking as many acres out of production as new schemes are bringing in. New methods of irrigation, drainage and tube wells are now beginning to overcome these problems. I visited the Land Reclamation Laboratories in Lahore and gained some idea of the complexity and magnitude of their task. In addition to recovery of previously productive land there are plans to bring a further 9½ million acres in Pakistan into production by irrigation. Even so the race between the growth of population and the provision of additional resources is desperately close.

Even without mechanization or increasing the area under cultivation productivity can be very greatly improved by the application of fertilizer and trace elements where necessary. This operation, however, depends upon the cheap and therefore industrial production of fertilizer which in turn depends upon cheap power. For this purpose the natural-gas fields of Pakistan are most convenient as they supply both the power and the raw material for fertilizer production.

Taking all this into account it is rather sobering to find that the Commonwealth share of the world's food production is not very impressive. Of the basic foods only rice, 24%, barley, 20%, and mutton, 23%, are in proportion to our population. All the others are way below 20% of the world's output. Coarse grains are only 9%, pig-meat is 5% and wheat 14%. This is in spite of the fact that many areas in Commonwealth countries regularly produce two and sometimes three crops per year already.

From what I have said I need hardly emphasize what is expected of engineers for agriculture especially in the less developed countries.

The next stage after food production is food preservation. There are one or two old-established methods of preserving food but generally speaking the whole

technique of food preservation is due to modern engineering methods. It has even gained the title of food technology and not even the homely and old-fashioned smoking and curing methods have managed to escape the food engineers.

Food technology is already most important in keeping out undesirable organisms and where there are large city populations. It is going to become even more important in tropical countries which are rapidly developing huge concentrations of population. This whole field of the preservation and distribution of food is wide open to the engineer. Freezing, canning, curing, spray and freeze drying, ionizing radiation and every kind of processing are all engineering problems.

Lastly, I think it is generally recognized that our harvest of food from the sea is still very underdeveloped. Both the methods of extraction and control could be considerably improved by modern equipment and scientific study.

ENERGY

Hand in hand with agriculture to supply the world's basic needs is energy. Energy is the very basis of modern civilization. Whichever way you look at it cheap, convenient and abundant power ranks with food as a means to raise standards of living.

The non-renewable sources of energy are coal, oil, and natural gas. The renewable sources are the sun, wind, water, wood, cow-dung and ultimately the breeder reactor in nuclear power. Also for the time being a very large proportion of the energy requirements for transport and agriculture is met by animal power in the shape of horses, oxen, camels, donkeys and elephants.

Distributed power in the form of electricity and gas, and independent power units in the form of internal-combustion engines are essential to high productivity in agriculture, transport and industry, and most convenient for personal use in the home and on the roads.

The point about all this is that there is a close relationship between the amount of energy available per head of the population and the state of material development of a country.

The explanation is obvious. Power for irrigation pumps and fertilizer factories raises agricultural productivity. Power for transport distributes agricultural products, brings raw materials to industry, distributes industrial products and transforms individual mobility. Power for industry makes it possible to harvest or extract the raw materials with greater efficiency and it is the very life-blood of industrial processing and manufacture.

Here I must again plunge into some figures to give you an outline of the energy situation in the Commonwealth. You will remember that the Commonwealth proportion of the world population is 24% and the Commonwealth covers 23% of the world's land area. Add to this the fact that 20% of the world's land rainfall falls on, and 18% of the 17 great rivers of the world flow through, Commonwealth countries. Finally, and most significantly, the production of energy by the Commonwealth is only 12% of the world's production even though India and probably several others have doubled their output in the last five years.

This figure of 12% has to be reduced to 10% if you leave out the oil produced in Bahrein, Kuwait and Qatar, and it means that Commonwealth countries at present only produce 3·5% of the world's oil and 3% of the natural gas.

You will find the over-all figures for energy production in Commonwealth countries in Appendix 5 as well as *per capita* consumption of commercial fuels in Appendix 6. These latter are the most revealing figures as they vary from 5·2 metric tons of coal equivalent in Canada to 0·6 in Pakistan.

Looked at in this way it is obvious that there is a very real urgency to increase the energy production and distribution in the Commonwealth.

In this field the engineer has almost unlimited scope and the solution of this energy problem demands more than skill and intelligence; it demands the services of far-sighted engineering administrators to exploit every indigenous source of energy and to plan the most economic form of energy production from other sources.

Australia for instance is very short of water for all purposes. The Snowy River Scheme will do much to meet immediate demands for energy and irrigation, but there are virtually no other sources of hydroelectric energy on the continent. Fortunately she has considerable resources for the production of nuclear energy.

New Zealand, on the other hand, has fairly large reserves of water power, but they happen to be on the South Island whereas the majority of the population is on the North Island. I see that the New Zealand Government are about to call for tenders to lay power cables across the Cook Strait. This immense engineering project is expected to cost about £19 million.

Engineers have also made it possible to harness the geothermal steam in the North Island to energy production which was otherwise merely a pleasant tourist attraction.

India has great reserves of coal but they happen to be mostly on one side of the subcontinent, while power is badly needed in many distant places which have no alternative sources. Unfortunately the cost of transporting the coal or the electrical energy is prohibitive so that there may be openings here for nuclear power stations.

In Canada the situation is that 85% of her electricity is provided by hydroelectric stations and she has still only tapped 28% of her resources of water power. I flew over the Hamilton Falls in Northern Quebec not long ago and I'm not surprised that the engineers have cast covetous eyes on so much energy going to waste.

Power is related to industrial productivity, but cheap power can also attract industry. In Ghana I saw the site for the Volta River Dam which will make it possible to exploit the bauxite deposits not far away for conversion into aluminium.

The giant Kariba Dam on the Zambezi will give a

tremendous stimulus to primary and secondary industry throughout the Federation of Rhodesia and Nyasaland.

Like Australia, South Africa is also short of water for all purposes, but on the other hand she has vast reserves of easily mined coal. As a result she is to build a plant for the conversion of coal into oil which is expected to meet one-seventh of the Union's present needs.

I have only referred to the large members of the Commonwealth. It is worth remembering that the smaller places have even more urgent problems without the material or economic resources with which to solve them. The Atlantic and Pacific islands need energy badly but unless they can harness the wind, the sun, or the tides, there is little scope for development.

INDUSTRY AND RESOURCES

It is becoming increasingly popular to look upon industry merely as a convenient way of giving employment. Industry does undoubtedly give employment, but that is not its basic function. Industry exists for three reasons:

1. It produces those things which are needed by a community to live a reasonably comfortable existence
2. It also produces those things which though not essential to human existence are very nice to have
3. It produces things which can be sold to other countries, preferably at an over-all profit.

I think it goes without saying that industry must also produce all those things which are needed by industry at all stages of the industrial process. In the less developed countries the first stage is the extraction of raw materials for use or export, followed by the production of the basic requirements of the manufacturing industries.

Industry has to satisfy the needs of the State as well as the needs and desires of the individual. In fact it is only by maintaining a proper balance between production for home consumption and production for export that a nation can maintain the upward curve of its standards of living. An adverse balance throws it upon the charity of more efficient or fortunate nations while a too favourable balance will merely widen the gap in standards between itself and its less efficient or fortunate neighbours. There can be no doubt that in the long run there is a greater chance of avoiding conflict if the material standards of people throughout the world are reasonably comparable.

It is difficult and probably misleading to try and generalize about the over-all position of industry in the Commonwealth. Having made the proviso I leave you to draw your own conclusions from the Appendices (7–11) which refer to this section. You will notice that in the renewable raw materials—other than food—production varies from 84% of the world's jute to 51% of wool to 11% of cotton and 10% of timber. In mining the Commonwealth produces only 12% of the world's iron ore, but more than its share of many other metallic ores. I have no figures for the manufacturing industries as a whole, but it is significant that the Commonwealth produces only 11% of the world's steel, 15% of the aluminium and 11% of man-made fibres.

If you take this in conjunction with the fact that in only five major Commonwealth countries do the manufacturing industries account for more than 20% of the gross domestic product while at least in six countries agriculture and forestry account for more than 40% of the gross domestic product, as well as the fact that we only produce 12% of the world's energy, the picture comes into rather sharper focus.

The implication is that in agriculture, basic industries and energy the Commonwealth output is not in proportion to its area or population.

I have already dealt with the energy picture and with certain exceptions there seems to be no reason why the Commonwealth as a whole should not produce its proper share of energy, but nuclear power will be necessary to achieve this in many areas.

Much the same applies to agriculture, but there the picture is rather distorted by the Indian subcontinent and Africa where at the moment there is a very high proportion of subsistence farming.

In mining the possibilities are very difficult to assess, but it would seem that we have hardly begun to tap the known mineral resources of Canada and Australia, while in India and Africa even the survey has not been properly completed. Some figures for Commonwealth mineral resources are contained in Appendix 11 which show that there is much to be developed.

The expansion of the manufacturing industries is a very complicated business which is really outside the scope of this lecture, although engineers are very closely concerned in it.

The total resources of the Commonwealth are probably roughly in proportion to its size, but this does not mean that the resources are evenly distributed. Each country has certain limiting factors and may lack certain raw materials, but on the other hand most countries have probably got something which is needed or wanted by others. There is no absolute need for countries to be self-sufficient; the real need is for Commonwealth countries to co-operate in such a way that the people can enjoy a reasonable standard of existence and the chance to develop their talents and their resources for the common good.

This means that methods of extraction, methods of refining, methods of processing and the transport system are the factors which can turn deposits of natural resources into wealth-producing assets. Where these are lacking, and this is by and large the situation in Britain, the only solution is the highest development of the human resources by a very advanced system of education and training. All these are problems for the engineer and the success with which they are tackled by imaginative engineers can transform the whole picture of industrial and economic activity in Commonwealth countries.

TRANSPORT AND COMMUNICATIONS

Having outlined the contribution which engineers can make to the development of agriculture, energy and industry in the Commonwealth, I must quickly add that none of their efforts would bear any fruit without an adequate system of transport and communications. It is virtually impossible to develop natural resources, or improve and augment the food situation, or even to enjoy the benefits of industrial enterprise without a comprehensive network of public and commercial transport and communications.

Indeed transport and communications are the means whereby the whole process of development is given purpose and direction and the only way by which the people can begin to adapt themselves to changing circumstances.

A community which is without the proper means of movement and contact is cut off from the world and therefore can only exist upon its own—usually very limited—resources. It cannot co-operate with its neighbours and its intellectual level is also bound to be restricted. As communications develop so its limit of experience is increased until it reaches the point where it is connected by the fastest transport and a virtually instantaneous communication system to all the other developed and mutually interdependent communities in the world.

Roads and paths made it possible for villages to co-operate, railways made it possible for districts to work together, while ships and aircraft have brought whole continents into contact for trade and commerce.

In the same way telegraphs and telephones, radio and newspapers are removing the barriers of ignorance and bringing the nations into closer concern with each other's problems.

Trade brought the old Empire into existence and communications kept it together. Now that it has become a Commonwealth of nations, transport and communications are making it possible to co-operate in every field of endeavour to the mutual advantage of all members.

A measure of the importance we attach to transport and communications in Britain is the amount of time and space devoted to its discussion. Anyone can start an argument any time by just mentioning British railways or British roads. And yet it is only 602 miles from Land's End direct to John o' Groat's and that's as far as you can go in these islands overland. If the Shetlands are included it makes a total of 768 miles. Compare this with Halifax to Vancouver, 2850 miles, Perth to Sydney, 2030 miles, Lagos to Kano, 518 miles, or Calcutta to Bombay, 1225 miles. To cover areas of this size with a network of roads and railways is a staggering task and yet it must be done if development is to take place. I think it is most significant that Canada has recently launched a programme of 'Roads to resources' so that the mineral wealth of the Northern wastelands can be exploited.

I sometimes wonder whether our transport engineers are fully aware of this enormous difference in scale between the problems of transport and communications in these islands compared to the larger Commonwealth countries.

There are similar difficulties in air transport. The distances, geography and climate in Britain are so different from other Commonwealth countries that it is not altogether surprising that there is an entirely different attitude to flying.

In Australia, India, Africa and Canada flying conditions, though uncomfortable at times and impossible for short periods, are such that aircraft can be operated for all purposes almost all the year round. As it is, the internal—or outback—flying in those countries is not unlike a country bus service. It certainly couldn't be more different from the sophisticated international air passenger systems which use the London airports.

This difference between British conditions and conditions in other Commonwealth countries also applies to aviation for agricultural purposes. Although there is a certain amount of agricultural aviation in Britain it is nothing at all compared to the potential employment of aircraft for this purpose in most Commonwealth countries.

The British aircraft industry is the most highly developed in the Commonwealth for the time being, but it cannot hope to continue to play a major part in the development of the Commonwealth unless it has the services of imaginative engineers who understand the needs and the conditions of the other Commonwealth countries.

We have certainly not reached the end in the development of transport systems. Aircraft capable of vertical take-off and landing, blind-landing systems, monorails, flat electromagnetic traction and air-cushion craft are all waiting to be converted into economic possibilities by engineers.

The Hovercraft type of vehicle in particular may easily revolutionize overland transport in the more remote regions of many Commonwealth countries. Its major advantage as I see it is that there is no need for expensive ground installations such as roads or railway lines. So long as the track is reasonably level and the gradients not too severe these craft ought to be able to operate over almost all kinds of country. In Canada, for instance, summer transport in the north is by barge up rivers and lakes. During the winter it is by caterpillar-drawn sled-trains. The Hovercraft ought to be able to operate equally easily summer and winter over snow and ice or water and land.

If this sort of craft has a reasonable operating economy there would seem to be openings for it in the outback of Australia, in Africa and in parts of India and Pakistan. In Bengal roads and railways have to be raised to keep them clear of flooding, and if they are to cross the Ganges delta or serve the islands in it, the bridge-building programme alone would be extremely expensive. Under these circumstances an amphibious

vehicle riding on an air-cushion might have considerable advantages.

Just after I had written that piece on the way from West to East Pakistan I came across a leading article in one of the Calcutta papers entitled 'Bengal air-cushions'. Amongst other things it asked 'Is it possible to revive some of the silted-up river channels as busy arteries of trade by use of that remarkable post-war development the Hovercraft?—if this type of craft proves economical . . . it may make some dying rivers useful again'.

In sea transport conditions are of course much the same all over the world. From the engineer's point of view therefore the two most fruitful fields of activity are in the process of shipbuilding and in the facilities for cargo-handling both in ships and ashore. Although it looks as if economics are against nuclear-powered merchant ships for the time being, it would be wrong to neglect their possibilities.

It seems a pity that the D.S.I.R. report on the shipbuilding industry in Britain should have caused so much trouble. A little mild and well intentioned criticism, even if its accuracy is disputed, should be treated as a signpost rather than as a slander. I admit it may be easier for me to take this attitude as I have to bear criticism rather more frequently than most.

Distance, geography and weather do not make quite such a difference to communications although here again the pattern of Press, radio and television development in Britain is governed by distance. Commonwealth countries have their own particular problems, but the need for posts and telegraphs, telephones, radio, Press and television is just as great in those countries and their development and installation is another of the engineer's tasks and responsibilities.

SCIENTIFIC RESEARCH

All progress in engineering ultimately depends on scientific research and there are two aspects of scientific research as far as the engineer is concerned. First there is the fundamental and applied research which provides the engineer with new materials and techniques and with new applications of known principles. Secondly, there are the huge research instruments which have to be designed and built by engineers to enable the scientist to continue his investigations.

Many of the great strides in engineering history were made before scientific research was used deliberately to find new techniques. In recent times, however, we have come to think of science as producing the new ideas and engineering as the means of exploiting them. So much so that we are inclined to forget that much scientific research is only possible with the aid of very advanced engineering. Computers, electron microscopes, accelerators, radio telescopes and satellites are no longer bits of apparatus that can be knocked up in the lab. All these instruments and many others are the products of a highly sophisticated engineering industry.

As the developing countries begin to establish their own basic and applied research organizations and their own centres of advanced teaching, these complicated instruments will be in great demand and it is reasonable to suppose that they will get more rather than less complicated in the future.

It can well be argued that the developing countries should not spend their time on basic research until they have established a comprehensive applied and industrial research organization.

From a practical point of view this is probably quite right, but on the other hand it would be a mistake to deny those people who are both capable and determined to do basic research the means to do their work in their own country. One or two nationally and internationally known figures in advanced science or engineering can do a very great deal by their example to enhance the reputation of science and engineering in the eyes of their fellow-countrymen and abroad. Dr. Siddiqui's recent election to the Royal Society is a good example. He is the Director of the Pakistan Council of Scientific and Industrial Research. There are, of course, many other Fellows of the Royal Society from Commonwealth countries.

Applied scientific and industrial research is, of course, essential in every country, if only because the conditions and the industrial activities vary in each country. Most of the Commonwealth countries have an organization similar to the British Department of Scientific and Industrial Research and although this Department is helping other countries in the development of roads and housing in the tropics, it would be a mistake to expect these organizations to investigate problems which only affect the economy of some other country.

EDUCATION AND TRAINING

If it's easy to start an argument about transport, it is just as easy to start a riot about education and training. But on this occasion I don't want to start an argument or a riot; I only want to draw your attention to some of the problems and difficulties facing engineering training and education in the Commonwealth.

One of the problems of engineering education is that it covers such a wide field. It includes science to manual skill and everything in between. It can be subdivided into a number of specializations and yet none of them are any use by themselves and all must have a proper appreciation of the part which engineering as a whole plays in the organization of modern life and in future development.

In Appendix 14 you will find some figures which are intended as a basis for comparison. These figures show the comparison between Commonwealth countries and they make it look as if the United Kingdom is reasonably well off. This is very far from the truth. To get an accurate picture of the position in Britain I recommend a comparison with our industrial competitors in Europe. For instance Unesco estimates that the number of University students per million of the population in

Britain is the lowest in Europe. No other country expects its students to graduate in three years.

Even plans for the future are not very encouraging. Sir Geoffrey Crowther has estimated that by the early seventies only about 4% (6% men, 2% women) of the children who are now just beginning their education will be able to carry it as far as a first or bachelor's degree. If the birth-rate continues to go up this proportion will of course go down unless more places are provided. He goes on to say 'Looking forward as best we can to the society of the 21st century, to its economy and above all to its technology, can we conceive that it will be adequately run by a generation of whom only 1 in 25 will have reached even a first degree? Is not this, in fact, a formula for national decline?' In all fairness I must add that Sir Geoffrey Crowther has not taken into account other forms of higher education such as Teacher Training, Colleges of Advanced Technology and Technical Colleges, nor all the students who will soon be taking the Dip. Tech., many of whom will be engineers.

Dr. Bowden of the Manchester College of Technology recently drew attention to another aspect of this problem. 'A recent statistical survey', he wrote, 'has shown that the British economy is expanding more slowly than that of most other European countries. On the assumption that the gross national product per head was 100 in 1950, West Germany has now reached 171, the O.E.E.C. countries average 139 and the United Kingdom only 122; and this despite the fact that the proportional rate of investment per worker in this country has been quite high during the last decade. It is clear that our investment has not been as productive as it should have been; I believe this may well be due to the inadequacies of our educational system.'

After that rather gloomy piece I must quickly add that in January of this year the Government produced a White Paper on 'Better opportunities in technical education' which sets out the proposed reconstruction of the system of courses for technicians, craftsmen and operatives in the Technical Colleges of England and Wales. These have still to be implemented but there seems to be every reason to hope that they will have a profound effect upon the whole pattern of technical education. At least they recognize that no new idea from a scientist or designer can become an efficient piece of equipment without the particular skill and ingenuity of technicians, craftsmen and operatives.

It only remains now for these plans to be matched in that unhappily large section of industry which still does not provide sufficient effective training for its young recruits.

It was with this situation in mind that the City and Guilds of London Institute agreed, at my suggestion, to run a Commonwealth Technical Training Week at the end of May and the beginning of June this year. There has been a most encouraging response from all Commonwealth countries and we hope very much that the Week's activities will attract the attention of young people, their parents and employers to the need for technically trained people and to the ways and means of getting that training.

This problem of higher education and technical training cannot be solved once and for all. Every country in the Commonwealth should look forward to progressive development which means that plans for education must look ahead to the needs of the next generation. Nigeria, for instance, has just published the Report of the Ashby Commission on Post-School-Certificate and Higher Education. This makes very interesting reading and shows what a tremendous problem they have to contend with.

There are at present 1800 students at Universities in Nigeria and a further 1000 in Universities overseas. The Commission estimates that only 900 students graduate from all Universities in one year whereas the need over the next ten years is for at least 2000 graduates a year. This means a University population of about 10000.

Three out of every four Nigerians work on the land; 17 shillings in every pound earned from Nigerian exports come from agricultural products, and yet only 20 men graduate in agriculture every year. The estimated need is 200 and 300 intermediate trained agricultural and veterinary officers.

This is only an estimate for the next ten years, but as soon as the impact of industrialization makes itself felt the demand for educated and technically trained people of all kinds will increase rapidly and progressively.

It is quite useless for the more fortunate countries to offer their help in building dams, power stations and factories if the managers and engineers needed to operate them are not available. Furthermore it doesn't take very long to put up the physical structures, but it may take anything up to 15 years for the people to gain sufficient knowledge and experience to run them.

If the various aid programmes, such as the Colombo Plan, are to be any lasting value, there must be a strong emphasis on technical education. Colleges, equipment and teachers are all badly needed, and teachers in particular will be needed for a great many years to come. This means that those countries with well-established higher technical educational facilities must take this added responsibility into consideration. Providing places for other Commonwealth citizens is only a temporary emergency solution; in the long run engineers and technicians must have their basic training in their own countries.

Dominating this whole worrying problem is the constant increase in population. India, for instance, plans to increase educational facilities by 5% per year and this means a very substantial increase in the bill each year. However, the population is increasing by about 2% per year so that the actual rate of increase in educational facilities is only just about 3% per year. This is a country where on the average only about 55% of the children of primary-school age go to school at all.

The British Government and British industry have agreed to establish and help to run a College of Technology in Delhi. I laid the foundation-stone two years

ago and when it is completed it will be a most valuable contribution to engineering education in India, but it all depends on whether Britain can provide the equipment and enough qualified professors. India has such an enormous expansion programme for technical education that our most effective help lies in providing teachers and in teaching those who are going to be teachers.

The significance of all this to engineers is that you cannot expect development and progress to be maintained unless you make sure that there are enough people in the next generation capable of carrying on your work. Only engineers themselves are capable of estimating what a nation's future needs are likely to be in graduates and technicians. Only engineers can decide what the qualifications should be in the light of the current state of engineering development. Only engineers who have themselves been properly educated can begin to impart the necessary knowledge into the next generation. It is not simply a matter of maintaining standards of knowledge and conduct; it means that you are ultimately responsible for the material well-being of your fellow-citizens.

PROFESSIONAL ORGANIZATION

In our system, and it also applies to several other Commonwealth countries, most professions are self-governing with very considerable powers over their members. Entrance is controlled by examination, professional ethics and practice are carefully watched and the whole tone of the profession is set by the professional organization.

I am in no position, least of all today, to judge whether the professional organization adopted by engineers in Britain is the most suitable one to enable you to fulfil your responsibilities. Equally I have no intention, for obvious reasons, of suggesting what the organization should be.

In a profession such as engineering, which covers such an immense field of activities, there are bound to be an increasing number of specializations. Even so I believe that all the specialists would agree that there is a general background common to them all. The thing to remember is that in education we all start off equally ignorant and only gradually build up a specialist knowledge. Then as administrative duties increase and your specialist knowledge tends to get a bit out of date, the importance of your own specialization gradually gets less and your appreciation of other specializations tends to grow, particularly when you ultimately find yourself successfully administering a complex of different kinds of engineering.

Any large engineering project must depend for its planning and successful completion on the closest possible co-operation and integration of many specialists. When it comes to exporting engineering the tendency is for Governments to commission a complete project —or package deal—from another Government or from a group or consortium of companies. The Durgapur (British), Rourkela (West German) and Bhilai (Russian) steelworks in India are examples of this and I should be very surprised if any of the engineering specializations were not involved in some degree in their construction. The interesting thing about these projects is that owing to the fact that there is such a close relationship between all aspects of engineering in Britain and India, the number of foreign experts necessary to build and equip these steelworks was considerably smaller at Durgapur than either of the other two.

Clearly the contribution which engineers can make to the development of the Commonwealth depends to a large extent upon the organization of the engineering profession both nationally and inter-Commonwealth.

I am delighted to know that the engineering institutions in Britain have been getting closer together in recent years with highly satisfactory results. The three host Institutions today have also taken the lead in bringing the sister bodies of the Commonwealth into closer touch. They organized the first Commonwealth Engineering Conference in 1946 and these have taken place every four years since then. Much has been achieved by these Conferences and by other means, and I hope this movement will grow and gather momentum so that the engineers of the Commonwealth can take full advantage of the relative freedom of movement and common language in the Commonwealth to practise or gain experience or to offer to collaborate freely with their Commonwealth colleagues. There is so much work to be done.

By the nature of things each Commonwealth country is bound to develop certain engineering specialities. For instance Canada has already gained considerable experience in hydroelectric work, India and Pakistan are deeply involved in irrigation problems, New Zealand is very advanced in dairy technology, and I expect there are some things of which Britain has a particular knowledge. If the Commonwealth is to make the most of these varied talents it is essential that the professional institutions should make determined and continuous efforts to keep in close contact with each other.

CONCLUSION

Different people may expect different things from engineers. I have suggested that they are necessary to meet humanity's basic needs of food and power, to develop and at the same time to conserve natural resources, to exploit the advantages of the industrial process and to enable science to continue its investigations. Their original thought and technical management are the main factors in a nation's prosperity. In fact while doctors are responsible for the bodily welfare of people, the engineer is responsible for the material welfare of nations. This is a very wide responsibility, but unless it is recognized by all the organizations which have the duty of educating engineers they will fail to turn out people capable of giving direction and purpose to the progress of the world.

In this lecture I have tried to show that the engineer is the key figure in the material progress of the world.

This is particularly important at this moment in history when we are beginning to realize the dangers in a situation where some countries are enjoying all the fruits of material progress and others none at all. There is a growing feeling that this unbalance is neither morally acceptable nor is it likely to improve the chances of peaceful conditions.

It is obviously impossible for the more fortunate countries to stop and simply wait for the others to catch up, and it is equally impossible for the others to catch up unaided. The gap in material standards can only be reduced by a real co-operative effort and since material development depends so much upon engineers, that co-operative effort means a co-operative effort by engineers.

The first necessity is an effective administrative framework so that the co-operation and collaboration between engineers of the world can take place. Take, for instance, engineering and technical training. There is said to be a shortage of engineers in the developed countries; there is no doubt about the shortage in the less developed countries. There is also a shortage of engineering teachers, and they are even more important because teaching does not only depend upon the number of teachers, it depends very much upon the moral and cultural example which they set. We cannot expect the direction or the momentum of development to be maintained without an adequate number of suitable engineers and technicians and the means of educating and training them.

I keep harping on the need for engineers to be educated as well as trained because I don't believe that specialist training necessarily affects those characteristics of the mind which are needed for human administration. The qualities of imagination, enthusiasm and compassion are present to a greater or lesser extent in all of us, but it needs the process of a general and liberal education to give them point and direction. Specialist training can give people the ability to make sweeping technological innovations, but it needs a broad and liberal education to enable people to foresee the effects of those innovations and to recognize how to introduce the fruits of modern science and engineering to the best advantage of the people.

That is the main task for the engineer in the future and the engineer of the Commonwealth can do this for one-quarter of the world's population. There are immense opportunities for engineers to increase the standards and prosperity of the countries of the Commonwealth, and it also offers every kind of engineering experience for the enterprising.

The target we should set ourselves in the Commonwealth is a reasonable material standard for all its people, and the main responsibility for reaching that target will rest on the engineer.

That, in the end, is the engineer's contribution to Commonwealth development, and it is my hope that the engineers of the Commonwealth will work together to reach that target in a spirit of trust and friendship.

APPENDICES

Many of the statistics in these Appendices were furnished by the Commonwealth Economic Committee for this express purpose. The Committee point out that, since international statistics necessarily describe many diverse things and activities under common headings, it is essential to use the figures with caution and with attention to the relevant notes. The mineral-resources picture is constantly altering with new discoveries of deposits and with changes in technical and economic conditions: thus the list of Commonwealth mineral resources is no more than a reasonable estimate, in the light of existing surveys and current conditions, of the reserves capable of use in the foreseeable future.

FOOD AND AGRICULTURE

Appendix 1. Commonwealth population: world comparisons 1958

	Total (thousands)	Density per sq. mile
United Kingdom	51870	551
Canada	17048	4
Australia	9846	3
New Zealand	2282	22
Union of South Africa	14418	31
South-West Africa	539	2
Ghana	4836	53
Federation of Rhodesia and Nyasaland	7780	16
Nigeria	33052	97
Other African territories	28045	25
India	397390	315
Pakistan	85635	235
Ceylon	9388	371
Federation of Malaya	6515	129
West Indies and Caribbean	3929	39
All other Commonwealth territories	9362	23
Commonwealth	681935	57
World total	2852000	55

Commonwealth proportion of world total = 24%
Source: United Nations statistical yearbook, 1959

Appendix 2. Labour force (Economically active population)

	Year	Total (thousands)	Percentage of total in	
			Agriculture	Manufacturing industries
United Kingdom	1951	22610	5	37
Canada	1960	6234	12	25
Australia	1958	3284	12	32
New Zealand	1956	817	16	24
India	1951	101775	71	9
Pakistan	1954–56	26100	65	11
Ceylon	1957	3508	57	9
Mauritius	1952	165	44	14
Jamaica	1953	615	49	12
Trinidad and Tobago	1956	267	25	17
Fiji	1956	93	57	6

Source: Yearbook of labour statistics 1960, except for Australia and Ceylon which are from national sources

Note: The figures above are only very broadly comparable, one of the main difficulties being the number of underemployed or part-time workers in agriculture

Appendix 3. Land area of the Commonwealth: world comparison (figures relate to latest available year or period)
(million acres)

	Total area	Land area*	Agricultural area: Arable and tree crops	Agricultural area: Pastures and meadows	Forested land	Other land: Unused but potentially productive	Other land: Built-on, wasteland, etc.
United Kingdom	60·5	59·7	17·6	30·4	4·1	—	8·4
Canada	2464·7	2271·9	100·3	54·1	845·0	179·7	1285·6
Australia	1903·7	1903·7	61·2	1081·6	98·5	—	662·5
New Zealand	66·4	65·7	1·2	31·2	23·0	1·2	9·8
Union of South Africa	302·2	285·4	27·0	213·6	2·4	—	59·3
South-West Africa	203·6	203·1	0·4	126·1	12·4	24·5	40·3
Federation of Rhodesia and Nyasaland	312·1	302·3	86·6	13·5	157·8	—	54·2
Ghana	58·8	58·8	13·1	—	37·6	—	8·1
Nigeria	238·9	238·9	55·1	—	79·2	—	104·5
Other African territories	689·3	658·6	20·6	143·4	121·4	67·1	336·8
India	812·7	812·7	395·4	30·2	126·1	53·1	208·0
Pakistan	233·9	233·9	61·1	—	5·2	—	167·7
Ceylon	16·2	16·0	3·8	—	8·7	—	3·7
Federation of Malaya	32·4	32·4	5·4	—	23·5	—	3·5
West Indies and Caribbean	66·8	62·2	6·1	0·7	46·3	5·1	8·6
All other Colonial territories	258·5	258·2	11·9	47·4	46·8	0·4	151·9
Commonwealth	7720·8	7463·5	866·8	1772·2	1637·9	331·1	3·1128
World (incl. U.S.S.R.)	33440	—	3450	6350	9850	13790	
Europe (excl. U.S.S.R.)	1220	—	380	190	370	280	
N. America	5320	—	570	690	1650	2410	
Latin America	5060	—	250	910	2420	1480	
Near East	2840	—	190	480	310	1860	
Far East	5170	—	900	680	1170	2420	
Africa	6180	—	550	1370	1620	2640	
Oceania	2110	—	60	1120	130	800	
	Per cent. of total area						
Commonwealth	100	97	11	23	21	4	40
World	100	—	10	19	29	41	
Europe (excl. U.S.S.R.)	100	—	31	16	30	23	
N. America	100	—	11	13	31	45	
Latin America	100	—	5	18	48	29	
Near East	100	—	7	17	11	65	
Far East	100	—	17	13	23	47	
Africa	100	—	9	22	26	43	
Oceania	100	—	3	53	6	38	

* Some of these figures are overstated since, where particulars of land area are not available, total area has been used

Source: F.A.O. production yearbook, United Nations Food and Agriculture Organization, 1959

Appendix 4. Estimates of the value of exports of agricultural products as a percentage of the gross value of agricultural production (including animal husbandry), 1958

United Kingdom	7
Canada	32
Australia	55
New Zealand	70
Union of South Africa	40
India	4
Ceylon	60

Note:
Production: Estimates of gross values of agricultural production (including animal husbandry) have been made from national sources. Definitions are only broadly comparable owing to differing methods of valuation etc.

Exports: (valued f.o.b.) include canned and dried meat, milk and fruits, dairy products, milled cereals, refined sugar, wine, fruit juices and vegetable oils, but exclude manufactured foods such as biscuits and confectionery, cigarettes, spirits and beer, processed raw materials such as wool tops and jute manufactures

ENERGY

Appendix 5. Energy production (figures relate to latest available year or period)

	Unit	World output	Commonwealth output	Commonwealth share, %
Coal	million tons	2400	348	15
Crude petroleum	million tons	940	113(a)	12
Natural gas	1000 million ft³	14499	439	3
Hydroelectricity	1000 million kWh	589	109	19
Total energy in coal equivalent (b)	million tons	4233	525	12

(a) Including 79 million tons produced in the British Protected States of Bahrain, Kuwait, and Qatar in the Middle East. If these are to be excluded, the Commonwealth figure for total energy should be reduced to 422 million tons coal equivalent, which represents 10% of the world total
(b) The conversion factors used are those given in the United Nations Statistical Yearbook, 1959

Sources: Commonwealth Economic Committee publications; Overseas Geological Surveys; United Nations statistical yearbook

Appendix 6. Consumption of commercial sources* of energy *per capita* in Commonwealth countries, 1958

	Metric tons of coal equivalent *per capita*
United Kingdom	4·741
Canada	5·187
Australia	3·644
New Zealand	1·934
South Africa	2·616
India	0·137
Pakistan	0·060
Ceylon	0·088
Rhodesia and Nyasaland	0·500
Ghana	0·139
Malaya	0·336

* Consumptions of non-commercial sources of energy, wood, bagasse, dung, etc., are not included in the above Appendix and no reliable estimates are available. They do, however, make a considerable contribution particularly with the less developed countrise

Source: United Nations world energy supplies 1955–1958, Series J, No. 3

INDUSTRY AND RESOURCES

Appendix 7. Industrial origin of gross domestic product of Commonwealth countries

Country	Year	Gross domestic product at factor cost. Total value, £ sterling million	Percentage distribution of gross domestic product					Col. 1 as percentage of cols. 1–4
			Agriculture, forestry and fishing	Mining	Manufacturing industries	Construction	Other	
			1	2	3	4	5	6
United Kingdom	1958	19778	4	4	35	6	51	8
Canada	1958	10633	7	4	26	7	56	16
Australia	July 1958 to June 1959	4397	17	3	33	—	47	32
New Zealand	April 1954 to March 1955	896	22	1	22	7	48	42
Union of South Africa	July 1957 to June 1958	1986	12	13	25		50	24
India	April 1957 to March 1958	8510	47	1	17		35	72
Pakistan	April 1958 to March 1959	1616	54	—	12	—	34	82
Ceylon	1958	412	51	—	5	9	35	78
Cyprus	1958	79	23	10	10	5	52	48
Nigeria	April 1956 to March 1957	807	63	1	2	11	23	82
Federation of Rhodesia and Nyasaland	1958	449	20	14	11	8	47	38
Malta	1958	38	7	9	9	—	75	28
Kenya	1958	207	42	—	10	4	44	75
Tanganyika	1958	169	59	3	7	7	24	78
Mauritius	1958	50	30	—	21	4	45	55
British Guiana	1956	43	25	11	11	10	43	44
Jamaica	1957	192	14	9	13	14	50	28
Trinidad and Tobago	1957	130	14	39	10	3	34	21

Source: United Nations statistical yearbook, 1959, except where otherwise indicated

Notes:

General: The estimates relate to gross domestic product at factor cost unless otherwise specified. The term 'gross' in this context means that the figures include depreciation, but the percentage contribution of each sector estimates the value added by the sector, and is therefore the best measure of the sector's contribution to the total product of the country. Column 6 shows agriculture as a percentage of agriculture, mining, manufacturing and construction. Column 5 (Other) includes transport, utilities, wholesale and retail trade, public administration and defence

Country Notes:

Australia: Estimates by C.E.C. based on Australian figures for gross domestic product and for net production of primary and secondary industry. Column 5 includes construction (column 4)

Union of South Africa: Total value = net domestic product at factor cost. Columns 3 and 4 relate to private enterprises only: Government enterprises in these and other industries except transport are classified in column 5
India: Total value = net domestic product at factor cost. Columns 3 and 4 include utilities
Pakistan: Total value = net domestic product at prices of 1949–52. Indirect taxes on exports included in column 5. Column 3 includes utilities. Column 5 includes construction (column 4)
Nigeria: Column 3 includes utilities and communications
Federation of Rhodesia and Nyasaland: Source: Monthly digest of statistics for the Federation, June 1960, p. 9
Malta: Column 2 includes construction (column 4)
British Guiana: Column 3 includes electricity
Trinidad and Tobago: Column 2 includes oil refining

Appendix 8. Primary products (figures relate to latest available year or period)

	Unit	World output	Commonwealth output	Commonwealth share, %
Wheat	million tons	245·3	34·0	14
Coarse grains,	million tons	378·8	33·5	9
of which: maize	million tons	188·4	11·0	6
barley	million tons	72·5	12·6	17
oats (a)	million tons	54·8	9·6	18
Rice	million tons	252·7	59·8	24
Milk (cows') (a)	million gal	60904	9535	16
Butter (excl. ghee) (a)	1000 tons	3791	627	17
Cheese (a)	1000 tons	2901	304	10
Beef and veal (a)	1000 tons	26715	3142	12
Mutton and lamb (a)	1000 tons	4951	1162	23
Pig-meat (a)	1000 tons	24664	1289	5
Oilseeds (as oil)	1000 tons	22678	5547	24
Sugar (cane and beet)	1000 tons	46888	7894	17
Tea	million lb	2004	1255	63
Cocoa	1000 tons	899	423	47
Tobacco	million lb	8262	1228	15
Rubber	1000 tons	1958	893	46
Wool (greasy basis)	million lb	5615	2850	51
Cotton	million lb	23491	2529	11
Jute (incl. allied fibres)	1000 tons	2474	1966	79
Hemp (hard)	1000 tons	805	270	34
" (other)	1000 tons	380	81	21
Softwood	1000 m^3	835990	85123	10
Hardwood	1000 m^3	748310	84166	11
Iron-in-ore	million tons	191	22	12
Nickel-in-ore	1000 tons	284	168	59
Copper-in-ore	1000 tons	3400	918	27
Lead-in-ore	1000 tons	2300	594	26
Zinc-in-ore	1000 tons	2600	720	28
Tin-in-concentrates	1000 tons	154	51	33
Bauxite (a)	1000 tons	20700	8089	39
Manganese-in-ore	1000 tons	5430	1298	24
Asbestos	1000 tons	2023	1262	62
Phosphate rock	1000 tons	34000	2190	6

(a) Excluding China (mainland)
Sources: Commonwealth Economic Committee publications; Overseas Geological Surveys; United Nations statistical yearbook

Appendix 9. Secondary industry (figures relate to latest available year or period)

	Unit	World output	Commonwealth output	Commonwealth share, %
Crude steel	million tons	300	33	11
Aluminium	1000 tons	4030	588	15
Sulphuric acid	1000 tons	41140	4794	12
Cotton yarn	million lb	16628	2990	18
Jute cloth	1000 tons	2038	1306	64
Raw wool consumption (clean basis)	million lb	3193	657	21
Man-made fibres	million lb	6832	732	11

Sources: Commonwealth Economic Committee publications; Overseas Geological Surveys

Appendix 10. Estimated value of the British Commonwealth mineral production, 1959

Country	Value of production, £ million	Percentage of total value	Chief minerals produced (value £ million)
United Kingdom	930·3	31·84	coal (829·2), gravel and sand (25·2), limestone (19·2), iron ore (10·4), igneous rocks (10·2)
Canada	895·5	30·65	petroleum (156·9), uranium (123·1), nickel (95·5), copper (86·7), iron ore (71·6), gold (56·0), asbestos (39·9)
Union of South Africa	387·0	13·24	gold (250·1), uranium etc. (48·7), coal (27·7), diamonds (15·7), asbestos (9·6), copper (9·6)
Australia	170·3	5·83	coal (36·4), iron ore (27·2), lead (28·3), copper (20·5), construction materials (15·2), gold (12·6), zinc (1·0)
N. Rhodesia	125·5	4·30	copper (117·3), cobalt (3·2), zinc (2·5), lead (1·0), manganese (0·7)
India	107·2	3·67	coal (71·1), manganese (7·1), salt (4·5), iron ore (4·3), gold (4·0), petroleum (2·3)
Malaya	42·5	1·45	tin (29·3), iron ore (11·6), bauxite (0·8), gold (0·3)
Trinidad	36·5	1·25	petroleum (34·6), natural gas (1·0), natural asphalt (0·9)
Brunei	34·6	1·18	petroleum (34·3)
Ghana	26·9	0·92	gold (11·3), diamonds (8·4), manganese (6·8)
South-West Africa	26·4	0·90	diamonds (16·3), copper (4·8), lead (3·1), zinc (1·0)
S. Rhodesia	25·0	0·86	asbestos (7·4), gold (7·0), coal (3·8), chrome (3·0), copper (2·0)
Jamaica	20·7	0·71	bauxite (11·0), alumina (9·4), gypsum (0·3)
New Zealand	18·4	0·63	coal (7·9), sand (7·2), limestone (1·4), gold (0·5)
Sierra Leone	13·7	0·47	diamonds (9·7), iron ore (3·8)
Nigeria	9·9	0·34	tin (4·2), petroleum (2·7), coal (2·0), columbite (1·0)
Cyprus	9·5	0·33	copper (4·0), iron pyrites (2·0), cupreous pyrites (1·9), asbestos (0·9)
Tanganyika	7·2	0·25	diamonds (4·5), gold (1·2)
Pakistan	7·1	0·24	coal (3·6), petroleum (1·7), salt (0·8), natural gas (0·7)
British Guiana	5·4	0·19	bauxite (4·6), diamonds (0·6)
Kenya	5·3	0·18	cement (2·5), soda ash (1·7), copper (0·5)
Uganda	4·7	0·16	copper (2·7), cement (0·9), cobalt (0·9)
Swaziland	2·1	0·07	asbestos (2·1)
Ceylon	1·6	0·05	cement (0·9), graphite (0·4), salt (0·2)
Fiji	1·2	0·04	gold (0·9), manganese (0·3)
Sarawak	1·0	0·03	bauxite (0·4), petroleum (0·3)
Other Commonwealth countries	6·5	0·22	phosphate rock (4·4), gold (0·6), salt (0·5)
	2922·0	100·00	

Source: Mineral Resources Division, Overseas Geological Surveys

Appendix 11. Estimates of Commonwealth mineral reserves

United Kingdom

COAL—anthracite and bituminous	168000 million tons
IRON (ore)	4600 million tons containing 1215 million tons iron
PETROLEUM	About 2 million tons
POTASH	140 million tons of potassium oxide
SULPHUR	60 million tons in anhydrite and gypsum

Canada

ASBESTOS	The world's major producer of chrysotile, of which Canada's known reserves are the largest in the world	
COAL—bituminous	62400 million tons	Total: 98800 million tons
sub-bituminous and lignite	36400 million tons	
CADMIUM (metal)	22000 tons recoverable as a by-product in zinc production	
COBALT (metal)	2000000 tons	
COPPER (metal)	6 million tons, plus unproved reserves	
GYPSUM	Large reserves	
IRON (ore)	At least 13635 million tons containing 5327 million tons iron	
LEAD (metal)	10 million tons measured and indicated	
MAGNESIUM (ore)	Large reserves	
MANGANESE (ore)	150 million tons of low-grade material in New Brunswick	
NATURAL GAS	Over 25 million million ft^3	
NICKEL	5 million tons, plus unproved reserves	
PETROLEUM	Over 500 million tons	
PHOSPHATES	25 million tons of ore containing 20% apatite	
PLATINUM METALS	Very large	
POTASH	Recoverable reserves estimated at 17500 million tons potassium oxide	
SULPHUR	46 million tons in pyrites and sulphur-bearing minerals. Reserves recoverable from natural gas at present being tapped estimated at 40 million tons. Further large reserves in bituminous sands and gypsum-anhydrite deposits	
THORIUM (metal)	170000 tons	
TITANIUM	One deposit with 150 million tons of ilmenite–haematite ore containing 35% titanium oxide; other deposits also known	
URANIUM (metal)	350000 tons	
ZINC (metal)	14 million tons proved	

Australia

ASBESTOS	Considerable reserves of blue asbestos (crocidolite). Relatively small reserves of other types of fibre

Australia (continued)

BAUXITE	33 million tons proved and hundreds of millions of tons indicated in the deposits in Queensland
CADMIUM (metal)	28000 tons recoverable as a by-product in zinc production
COAL—anthracite and bituminous	15250 million tons
COAL—sub-bituminous and lignite	42160 million tons
COAL—Total:	57410 million tons
COPPER (metal)	800000 tons proved plus other indicated reserves
IRON (ore)	720 million tons containing 419 million tons iron. Additional large reserves of lower-grade ore
LEAD (metal)	13 million tons measured and indicated
MICA	Extensive
RUTILE	2·5 million tons. Also reserve of ilmenite
SULPHUR	14·9 million tons in pyrites and pyrrhotite and in lead and zinc sulphides. 140 million tons in gypsum
THORIUM (metal)	40000 tons
TIN (metal)	30000–40000 tons
TUNGSTEN (ore)	32 million lb of tungsten oxide
URANIUM (metal)	12000 tons
ZINC (metal)	11 million tons measured and indicated
ZIRCON	About 1·5 million tons

Christmas Island

PHOSPHATES	Over 30 million tons containing 80% tricalcium phosphate

Nauru Island

PHOSPHATES	About 65 million tons containing 83% tricalcium phosphate

New Guinea

BAUXITE	500000 tons

New Zealand

COAL—bituminous	124 million tons
COAL—sub-bituminous and lignite	908 million tons
COAL—Total:	1032 million tons
IRON (ore)	496 million tons containing 250 million tons iron

Union of South Africa

ANTIMONY (metal)	Estimates vary between 80000 and 150000 tons
ASBESTOS	Considerable reserves of chrysotile, amosite and blue asbestos. The only commercial source of amosite
CHROME (ore)	Largest free-world source of chemical-grade chrome ore. Total reserves 100 million tons of chemical-grade ore plus about 2 million tons of low-grade metallurgical ore suitable for blending
COAL—bituminous	67000 million tons
COPPER (metal)	800000 tons proved, plus additional unproved reserves
DIAMONDS	Large
GOLD	500 million ounces
ILMENITE	2 million tons
IRON (ore)	3500 million tons containing 1600 tons iron. Large reserves of lower-grade ore
MANGANESE (ore)	60 million tons containing 30–54% manganese
PHOSPHATES	85 million tons containing 10–12% phosphorus pentoxide, with additional large reserves of lower-grade ore
PLATINUM METALS	Large
THORIUM (metal)	12000 tons
TUNGSTEN (ore)	Large
URANIUM (metal)	300000 tons

South-West Africa

COPPER (metal)	Nearly 500000 tons
DIAMONDS	Very large
IRON (ore)	Possibly up to 300 million tons containing 120 million tons iron
LEAD	1·3 million tons
MANGANESE	Large
ZINC (metal)	Nearly 500000 tons

India

BAUXITE	28 million tons possibly of commercial grade
COAL—anthracite and bituminous	38100 million tons
COAL—sub-bituminous and lignite	4500 million tons
COAL—Total:	42600 million tons

India (continued)

COPPER	About 4 million tons proved and probable plus unproved reserves
ILMENITE	50 million tons
IRON (ore)	21300 million tons with an estimated 85000 million tons of lower-grade ore totalling 37940 million tons iron
LEAD (metal)	About 100000 tons proved
MANGANESE (ore)	112 million tons, 60 million tons of which contain more than 45% manganese
MICA	No figures available. The free world's largest source of strategic grades of mica
NATURAL GAS	1000 million ft³
PETROLEUM	About 75 million tons
PHOSPHATES	About 700000 tons containing 20–25% phosphorus pentoxide. Additional 8 million tons with 24–27% phosphorus pentoxide
RUTILE	2 million tons
THORIUM	240000 tons
ZINC (metal)	About 120000 tons proved and estimated

Pakistan

COAL—sub-bituminous and lignite	104 million tons
IRON (ore)	60 million tons containing 36 million tons iron
NATURAL GAS	About 5 million million ft³
PETROLEUM	About 3 million tons

Ceylon

GRAPHITE	Large deposits
ILMENITE	4 million tons

Ghana

BAUXITE	230 million tons
DIAMONDS	Extensive
MANGANESE	Still large but becoming depleted
GOLD	Extensive

Federation of Malaya

BAUXITE	Possibly 10 million tons
COAL—sub-bituminous	21 million tons
ILMENITE	Considerable
IRON (ore)	55 million tons containing 33 million tons iron
TIN (metal)	1·5 million tons plus reserves undeveloped

Cyprus

COPPER (metal)	200000–250000 tons with additional unproved reserves

Nigeria

COAL—sub-bituminous	240 million tons
COAL—lignite	Over 60 million tons
COAL—Total:	Over 300 million tons
COLUMBITE	Mined with tin, Nigeria being the world's largest producer
LEAD (metal)	About 100000 tons indicated
PETROLEUM	About 3·5 million tons
PHOSPHATES	Small reserves known
THORIUM	By-product of columbite working, 12000 tons
TIN (metal)	100000 tons proved and estimated plus an equal quantity as inferred reserves
ZINC (metal)	About 70000 tons indicated

Federation of Rhodesia and Nyasaland

Southern Rhodesia

ASBESTOS	Considerable reserves of chrysotile containing a high proportion of spinning-grade fibre
CHROME (ore)	6 million tons of metallurgical-grade ore. 80 million tons of chemical-grade chrome, commercial and sub-marginal deposits together
COAL—bituminous	Over 1000 million tons
COPPER (metal)	Over 250000 tons
IRON (ore)	144 million tons containing 86 million tons iron. Further large reserves of lower-grade ore
LEAD (metal)	210000 tons
LITHIUM MINERALS	Large
PHOSPHATES	37 million tons containing 8% phosphorus pentoxide
ZINC (metal)	450000 tons

Northern Rhodesia

COBALT (metal)	Over 350000 tons
COPPER (metal)	24 million tons. Extensive additional but unproved tonnage
IRON (ore)	50 million tons containing 32 million tons iron. Further large reserves of lower-grade ore

Federation of Rhodesia and Nyasaland (continued)

LEAD (metal)	430000 tons proved, plus 300000 tons indicated
MANGANESE	Large deposits in northern part
ZINC (metal)	700000 tons proved plus 700000 tons indicated

Nyasaland

BAUXITE	60 million tons, averaging 43% alumina
THORIUM (metal)	8000 tons

Kenya

COPPER (metal)	30000 tons in proved, inferred and indicated ore
GRAPHITE	100000 tons with 10% graphite
SODA ASH	Large

Uganda

COBALT (metal)	20000 tons. Also 7 million tons of inferred ore
COPPER (metal)	200000 tons, plus 7 million tons of inferred ore
PHOSPHATES	Over 200 million tons containing 13% phosphorus pentoxide

Tanganyika

COAL—bituminous	Over 250 million tons
COPPER (metal)	14000 tons
DIAMONDS	Extensive
LEAD (metal)	Minable reserves estimated at about 10000 tons

Sierra Leone

DIAMONDS	Extensive
IRON (ore)	200 million tons containing 120 million tons iron. Further reserves of lower-grade ore
RUTILE	Large reserves

British Borneo

PETROLEUM	About 75 million tons in Brunei and Sarawak
PHOSPHATES	60000 tons containing 10–20% phosphorus pentoxide
BAUXITE	5·5 million tons in Sarawak

Hong Kong

IRON (ore)	10 million tons containing 4 million tons iron

Jamaica

BAUXITE	500–600 million tons with an average recoverable alumina content of 42%
GYPSUM	13 million tons minimum
PHOSPHATES	100000 tons containing 25–31% phosphorus pentoxide

Trinidad

PETROLEUM	55 million tons

British Guiana

BAUXITE	About 70 million tons containing 60% alumina
COLUMBITE	1 million yd³ averaging 2lb of columbite concentrates per yd³
DIAMONDS	Considerable
GOLD	Considerable low-grade alluvial deposits
MANGANESE (ore)	About 5 million tons of 40% grade

Fiji

MANGANESE	Many small deposits are known
PHOSPHATES	Up to 200000 tons iron-aluminium phosphate

British Solomon Islands

PHOSPHATES	8 million tons iron-aluminium phosphate

Ocean Island

PHOSPHATES	About 8 million tons containing 85% tricalcium phosphate

Seychelles

PHOSPHATES	Small reserves known

Swaziland

ASBESTOS	Considerable reserves of chrysotile
COAL—anthracite	About 35 million tons
IRON (ore)	62 million tons containing 40 million tons iron. Further 280 million tons of lower-grade ore.

Source: Economic development in the Commonwealth, Central Office of Information, 1960

TRANSPORT AND COMMUNICATIONS

Appendix 12. Railways and telephones

	Railways		Telephones
	Route distance	Total track	
United Kingdom	18565	50510	7532000
Canada	44209	59394	5118253
Australia	26331	32693	2122251
New Zealand	3400	—	641342
South Africa	13438	17870	828434
India	34750	50369	475000
Pakistan (East and West)	7050	—	63000
Ceylon	900	—	30017
Ghana	600	—	24917
Malaya	1025	1303	61736
Nigeria	1780	—	40000
Southern Rhodesia	1284	—	21291

Source: Official national statistics

SCIENTIFIC RESEARCH

Appendix 13. Commonwealth Institutes and Bureaux

Commonwealth Mycological Institute, Kew

Commonwealth Institute of Entomology, British Museum

Commonwealth Institute of Biological Control, K.W. Neatby Building, Ottawa

Commonwealth Agricultural Bureaux

Animal Breeding and Genetics, Edinburgh

Animal Health, Weybridge

Animal Nutrition, Aberdeen

Dairy Science and Technology, Reading

Forestry, Oxford

Helminthology, St Albans

Horticulture and Plantation Crops, East Malling

Pastures and Field Crops, Hurley

Plant Breeding and Genetics, Cambridge

Soils, Rothamsted

EDUCATION

Appendix 14. Commonwealth educational statistics

	Source	Units	U.K.	Canada	Australia	New Zealand	South Africa	India	Pakistan
1. Total population, mid-1958	Unesco	millions	51·9	17·0	9·8	2·3	14·4	397	85·6
2. Total public expenditure on education (a)	Unesco	£ million (b)	691 (1957–58)	339 (1957)	87 (1958–59)	39 (1959–60)	63 (1958) (c)	163 (1958–59)	20 (1957–58)
3. (2) as a percentage of national income	Unesco	per cent.	4·0 (d)	3·9	2·2	4·1	3·0	1·7	1·3
4. Numbers graduating in science and technology (or completing equivalent courses) in a year	High Commissioners	thousands	14·3 (1959) (e)	5·9 (1958–59)	1·9 (1959) (f)	0·38 (1959)	1·1 (1958) (g)	29 (1958)	3·2 (1958–59)
5. (4) as a proportion of total population	—	no. per million	280	349	190	160	77	72	37

Notes: (a) Generally includes capital expenditure; (b) Converted to £ on basis of exchange rates; (c) Excludes capital expenditure; (d) Percentage in 1957; (e) Source: Ministry of Education; (f) Excludes postgraduate degrees (0·2), includes technical-college diplomas (0·7); (g) University degrees (bachelors' degrees and diplomas only) in engineering, mathematics, and pure sciences (Source: Annual report of Department of Education, Arts and Science, 1959)

PROFESSIONAL ORGANIZATIONS

Appendix 15. Constituent members of the Commonwealth Engineering Conference

The Institution of Engineers, Australia

The Engineering Institute of Canada

The Institution of Engineers, Ceylon

The Institution of Engineers, India

The New Zealand Institution of Engineers

The Institute of Engineers, Pakistan

The Rhodesian Institution of Engineers

The South African Institution of Civil Engineers

The South African Institute of Electrical Engineers

The South African Institution of Mechanical Engineers

The (U.K.) Institution of Civil Engineers

The (U.K.) Institution of Mechanical Engineers

The (U.K.) Institution of Electrical Engineers

British engineers discuss traction, telecommunication in Poland

VISIT TO THE ASSOCIATION OF POLISH ELECTRICAL ENGINEERS, 19th–26th MARCH 1961

The Institution and the Association of Polish Electrical Engineers jointly organized a scientific–technical conference on new developments in electric traction and telecommunication in Great Britain. The conference was held in Warsaw in March 1961, and lectures were given by members of The Institution. The proceedings were opened by the President of the Association of Polish Electrical Engineers.

This is a short account of the conference and other activities undertaken by The Institution's visiting team.

THE keynote of this visit was struck immediately the British party arrived at Warsaw airport. They were met by representatives of the Association of Polish Electrical Engineers and by Mr. and Mrs. H. J. Kelly of the British Council, and presented with detailed arrangements for the conference and the tour of Poland included in it. Some of these Polish gentlemen were already known to members of the visiting party.

The party comprised five persons who were to deal with traction and four who were to deal with telecommunication subjects at the conference. Everything that happened during this visit reinforced those friendships, and many new ones were formed.

The city of Warsaw

On the morning of the first day, we were shown something of the rebuilding of the city of Warsaw. We had, of course, known that the old city had been rebuilt line for line as it existed before its destruction during the war. Until we were shown the rebuilding, we had not realized either the extent of the rebuilding or the care with which it had been done. We found it easy to understand the indomitable spirit behind this rebuilding, which is its justification.

Later that day, the traction party were taken to the Technical Institute, where research on traction subjects was being carried out by 20 engineers under the leadership of Prof. A. Jablonski. Other researches in electrical subjects were being made, and a short-circuit testing station and h.v. laboratory were being built.

At the same time the telecommunication party visited the research laboratory of the Ministry of Posts and Telegraphs, wonderfully situated in pine-woods to the east of Warsaw. There they had the pleasure of meeting Dr. Z. Szpigler, the Director, and senior members of his staff and seeing some of the work carried out. When fully occupied, the buildings, which are new, will house over 400 people.

The formal sessions of the conference were held in a building that is used jointly by all kinds of engineers in Warsaw—the 'Dom Technika'. It was attended by some 300 Polish engineers, all of whom had received Polish translations of the papers to be presented and discussed and many of whom had prepared questions. The proceedings opened with a very friendly welcome from the President, Prof. T. Kahl, to which Mr. J. A. Broughall replied on behalf of The Institution, bringing the good wishes of the Council for the conference and to the Association of Polish Electrical Engineers.

The conference

The meeting then divided into two parts, one dealing with traction and the other with telecommunication subjects. The traction section was held under the chairmanship of Prof. J. Podoski. The telecommunication part of the conference was chaired by Prof. S. Kuhn. In both parts the wide technical knowledge and excellent command of English of the chairmen were of great value.

The first day's session of the traction section opened with Mr. H. H. C. Barton's paper on 'Power supply questions associated with recent developments of traction operated on the d.c. system'. This dealt particularly with the d.c. electrifications of the Southern Region, British Railways, and London Transport Executive. It was followed by Mr. G. R. Higgs's paper on 'Traction equipment', including references to British experience in supplying equipment for 3 kV d.c. railways, which is the system used by the Polish State Railways.

After an adjournment for lunch in the Engineers' Club, which is housed in the same building, Mr. D. M. H. Rooney presented his paper on 'Overhead equipment', his co-author, Mr. O. J. Crompton, being prevented from attending by ill-health. The paper, which gave particulars of many new developments, some of them associated particularly with h.v. a.c. traction, led to a lively discussion and was followed by a film entitled 'Power to the pantograph', which had been provided with a Polish commentary. This was greatly enjoyed, and, in fact, a copy of the film was, at the request of the Association of Polish Electrical Engineers, left in Poland.

On the second day of the traction section, Mr. W. G. Jowett presented his paper on 'New developments in Diesel traction', which also gave rise to a lively discussion. The conference was concluded by Mr. Broughall's paper 'Recent achievements in Great Britain on the 50 c/s system', which was illustrated by a film 'Railway electrification at industrial frequency', for which a Polish résumé had been provided. This paper gave rise to the longest discussion of all, since, for certain future electrifications, the question whether to use this system in Poland or to continue entirely on the 3 kV system is under consideration.

The first day of the telecommunication section was taken up with lectures on 'U.K. developments in radiocommunications' and 'Line communications' by Mr. H. Stanesby and Mr. D. G. Holloway respectively, and the second day was devoted to lectures by Mr. T. H. Flowers on 'Electronic switching' and Mr. L. Lewin on 'Long-distance waveguide transmission'. Each lecture was followed by a spirited discussion, during which it became clear that speakers were very much more interested in general trends of development than in technological detail.

The formal proceedings were concluded by a dinner party given by our hosts, at which Mr. Broughall, in the name of The Institution, presented a book 'The spirit of London' inscribed by the visitors as a souvenir of a visit that everyone

Some of the visiting team with their Polish colleagues at Zakopane

Left to right: W. Ostaszewski, Prof. St. Plewako (Chairman, Electric Traction Section, Association of Polish Electrical Engineers), Mrs. Plewako, J. A. Broughall (hidden), A. Holownia, J. H. Ostaszewicz, W. G. Jowett, and L. Lewin

agreed had been not only of technical value but in every way a case for mutual congratulation among all concerned.

Tour of Poland

After this, we travelled by sleeping-car to Wrocław, where we visited a locomotive- and carriage-building works (Pafawag) employing 7000 men. This works showed a fascinating combination of modern techniques, assisted by an inherited skill in the working of steel. The rolling-stock that results seemed to be of a very high quality and to be finding a market in many parts of the world. We also visited an electrical-machine factory, M.5, employing about half this number of men, where a large variety of rotating electrical machines were being made, ranging from traction motors and mill motors to turbo-alternators. It was of interest that, at these two factories, electric locomotives would be manufactured under licences granted by two British manufacturers.

We continued our journey by train to Krakow, passing through a heavily industrialized belt at Katowice, including steelworks and mining plants extending for some 50 miles. At Krakow, which is a very important cathedral and university city and which fortunately was little damaged during the war, we were entertained at the Students' Club and, but for the absence of a pianist who was apparently too young to stay up so late, we would have enjoyed a cabaret.

Up again in the early hours of the following morning, we were taken into the mountains on the southern border of Poland, where we found Zakopane in snow and the surrounding mountains, to which we were taken by rope railway, heavily embedded in snow and fog.

On our final day, we were taken by road 250 miles from Zakopane to Warsaw. The coach was one of two fleets of modern coaches and was well filled throughout its journey. We did not pass more than two or three lorries on the whole of the journey over roads that reminded us—apart from their surface, which was excellent—of those of our youth: there was more horse-drawn traffic than there were motor-cars. Freight traffic was carried by rail.

Saying good-bye

At the conclusion of this journey, we were privileged to entertain some 12 Polish engineers to dinner, including the members of the local committee—Messrs. W. Ostaszewski, J. H. Ostaszewicz and A. Hołownia. These engineers had been with us throughout our travels. They spoke perfect English and added greatly to the pleasure of our visit. We should also like to mention Mr. Frydryszak and Mr. Trafisz, who undertook the difficult task of translating the questions of the Polish engineers into English and our replies into Polish.

The theme on this last occasion was like that at the first, coupled with the firm hope that arrangements would be possible to allow us to have our Polish friends in Britain for a return match.

J. A. B.

EXHIBITION ON TECHNICAL TRAINING

One of the features of Commonwealth Technical Training Week was an exhibition on technical training held at the Royal Exchange, London, from the 29th May to 3rd June 1961. Its theme was the opportunities for training and education in industry, commerce and the professions.

The exhibition consisted of 31 stands. Among the industries and careers represented were insurance; the Royal Air Force; furniture; iron-founding; aluminium; copper; paper and board; printing; transport; gas; the Civil Service; heating and ventilating; packaging; banking; petroleum; the Post Office; iron and steel; civil, mechanical and electrical engineering; coal; electricity; surveying; and secretarial work. One stand served as a general information bureau and was staffed by representatives of the Youth Employment Service and the City and Guilds of London Institute. Representatives of the various sponsoring bodies were available to answer questions.

The three senior engineering institutions participated jointly in the exhibition. In the centre of their stand was a scale model of the Grudie Bridge hydroelectric power station; a painting on the backcloth depicted some of the activities in which civil, mechanical and electrical engineers are engaged.

The exhibit of the three institutions

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FUNDAMENTAL PARTICLES

Weak interactions, strangeness, baryonic charge—these are some of the phenomena discussed in this article, which is based on an informal lecture to the East Anglian Sub-Centre of The Institution at Cambridge.

The author is Jacksonian Professor of Natural Philosophy, University of Cambridge.

Prof. O. R. FRISCH, O.B.E., D.SC., F.R.S.

A HUNDRED years ago, about 80 different kinds of atom had been identified by the chemists and were thought to be the fundamental particles of matter. But in 1896 a common component of all atoms was discovered—the electron. In 1911 the existence of atomic nuclei was recognized, and in 1913 that of isotopes. After that, the hydrogen nucleus became a plausible component of all nuclei and came to be called the proton (Greek for 'the first one').

On paper, one could construct all atoms from protons and electrons, and it was thought that these were the two fundamental particles from which all matter was made. In addition, there was the light quantum or photon. This 'atom of radiation', which behaved like a particle of zero intrinsic mass moving always at the speed of light, had been recognized as early as 1905.

Discovery of the neutron

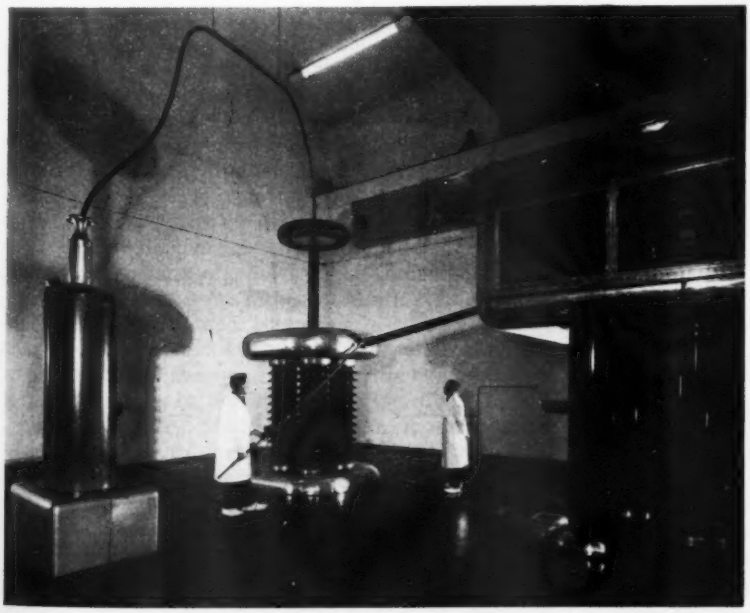
This state of simplicity did not last long. In 1932 the neutron was discovered, a sort of proton without charge. This made it possible to construct nuclei from nucleons alone—i.e. from protons and neutrons—and the theoreticians were relieved. The attempt to squeeze electrons into the small space of a nucleus had given them many a headache.

But why should the positive and the neutral particle be of nearly equal weight, while the negative one was more than 1800 times lighter? The labels positive and negative attached to the two kinds of electricity were purely arbitrary. Why then did nature treat them so differently? Part of the answer came in 1928 when Dirac's theory of the electron, constructed primarily to accord with the principle of relativity, turned out to predict the existence of positively charged electrons. A few years later such positrons were discovered in cosmic radiation, and soon also made in the laboratory.

After that, the existence of negative protons was confidently predicted, although they were not observed until 1955. Today we feel sure that to every kind of particle there exists an antiparticle, with the same mass but opposite in every other respect (electric charge, magnetic moment, etc.). In our part of the universe, negative electrons and positive protons prevail, but some distant galaxies might be made of antimatter, composed of positrons, negative protons and antineutrons. So nature at large may yet be charge-symmetric.

By itself a positron is stable; but in travelling through matter it soon encounters an electron, the two become annihilated, and their energy is turned into radiation, i.e. photons. Conversely, if high-energy photons pass through matter we observe the creation of electron pairs consisting of one positive and one negative electron. The rest energy of an electron, computed by Einstein's formula $E = mc^2$, is 0·511 MeV. A good many radioactive substances emit γ-rays of more than twice this energy, enough to produce electron pairs.

Other particles have much higher rest energies and are not that easy to produce, even though some can be made singly and not merely in pairs. Fortunately, the cosmic radiation provides us with protons and other bullets of almost unlimited energy, and nearly all the new kinds of particle mentioned in this article were first observed through the study of the cosmic rays.



1 *Equipment associated with the 600 keV ion gun which supplies pulses of protons to the 15 MeV linear accelerator injector for Nimrod*
From left to right: 600 kV electrostatic generator, storage capacitor and h.v. cubicle

From 1947 onwards, more and more of the work has been done with cyclotrons and synchrotrons, which give well collimated beams of high-energy particles; in this way observations can be made much more rapidly. (Fig. 1 shows some of the equipment used in conjunction with Nimrod, the 7GeV linear proton synchrotron.) Indeed today it is difficult to digest the observations fast enough. Some thousands of interesting particles a day are being photographed in cloud chambers, bubble chambers, and on photographic emulsions; special semi-automatic measuring machines have been built to study the angles and curvatures of their tracks, assisted by large electronic computers.

Mesons and hyperons

Let us now take a look at these particles. The π-meson (Greek for 'the intermediate one'), or briefly pion, shares with the positron the distinction of having been foreseen. Yukawa argued in 1935 that there should exist quanta of the nuclear force, which held nucleons together in nuclei—just as photons were quanta of the electromagnetic force; they should be about 300 times heavier than electrons and should carry the same (or opposite) electric charge. Such particles, both positive and negative and 273 times heavier than electrons, were eventually discovered in 1948, in cosmic radiation.

A neutral pion was found soon afterwards. It is its own antiparticle—like the photon—and explodes into two photons before it has gone more than 0·001 mm. That was a smart piece of detection, based on a careful study of the unexpectedly penetrating γ-rays that came from a cyclotron target in which charged pions were being made.

Cosmic radiation contains somewhat lighter particles as well, the μ-mesons or muons, 207 times as heavy as electrons. At sea level, they are much more common than pions; so they were the first to be discovered and were at first mistaken for the ones Yukawa predicted. We still have no theory for them; apart from being unstable, they seem to be just scaled-up, overweight electrons.

From 1948 onwards, a number of new particles were discovered that were soon nicknamed the 'strange particles' because of their complex behaviour. At one time it looked as if every physicist would soon have one for himself.

With a world production of about one specimen a day, progress was very slow until 1953 when the first proton synchrotron, the cosmotron at Brookhaven near New York, made much larger numbers available for accurate study. Within two years the confusion was cleared up, and the picture today is substantially that of 1955. There are now a positive and a neutral K-meson half as heavy as protons, and six particles heavier than protons, called hyperons (Greek for 'excessive one'), denoted by Λ^0, Σ^-, Σ^0, Σ^+, Ξ^- and Ξ^0. Each of these eight particles has its own distinct antiparticle.

If all these particles are being created all the time in cosmic radiation, why is the world not full of them? Because they are all unstable: they turn spontaneously, within a split second, into stable ones, such as protons, electrons or photons. Many of those transformations are made possible by the existence of a very inconspicuous particle, which I have not yet mentioned—the neutrino. Let me explain its role.

Conservation laws

Every transformation of a particle has to obey a number of conservation laws. The conservation of energy (or mass, the two being equivalent according to the relativity theory) demands that the resulting particles must be jointly lighter than the original one; the difference in mass appears in the kinetic energy with which the new particles fly apart. Electric charge is also conserved. So when a nucleus contains too many neutrons, one of them can transform itself into a proton; but charge conservation demands that an electron be emitted at the same time. That process—β-radioactivity—has been known for many years. Conversely, in a nucleus with too many protons, a proton can turn into a neutron and a positron.

This is not the whole story. Protons, neutrons and electrons all possess the same amount of spin (i.e. intrinsic angular momentum); and, according to quantum mechanics, these spins must always be in line, pointing either in the same or in opposite directions. Turning a proton into a neutron and an electron would therefore mean turning a system of unit spin into one with either two units or no spin, and that is impossible because angular momentum is conserved.

Universal scavenger

So we need an extra unit spin, and the neutrino provides just that. Its existence was first suggested by W. Pauli about 1930. At that time it was known that some radioactive nuclei emit electrons, and the disturbing fact had been discovered that, of the energy available in such transformations, the electrons carried only a fraction that varied from one electron to another. So Pauli suggested an 'invisible thief': a light, neutral particle that stole part of the available energy and escaped unobserved, leaving the remainder to the electron.

For a quarter of a century, these neutrinos eluded all efforts to detect them. But at last Pauli saw his long shot come home: with a set of enormous scintillation counters, placed next to a big atomic pile, neutrinos were observed, a few per hour, as expected.

A neutrino has nothing but spin; but that is enough to make it indispensable. Some of the strange particles can do without its help; for instance, a Λ^0-hyperon can break up into a proton and a negative pion; but a charged pion—having no spin—cannot turn into a muon or an electron without forming a neutrino as well. So today we regard the neutrino more kindly, not as a universal thief but as a universal scavenger that prevents the world from becoming cluttered up with strange particles and unbalanced nuclei. It charges a high fee:

over 10% of all the energy produced in stars is carried away, irretrievably, by neutrinos. But who cares?

To go back: the conservation laws of energy, charge and angular momentum severely limit the transformations possible; but they offer no reason why, for example, a proton should not break up into a positron and a neutral pion. Yet protons can turn into neutrons, and they can be formed from hyperons. So we assume that protons, neutrons and the six hyperons—the eight baryons ('heavy ones', in Greek)—have something in common, which we call baryonic charge, and that this quantity is conserved. This seems reasonable; all baryons seem to be sources of nuclear force. Antibaryons, of course, have negative baryonic charge.

Weak interactions

All the conservation laws so far mentioned—of energy and mass, momentum, angular momentum, electric charge and baryonic charge—hold rigorously in all processes that have been studied so far. But there are two quantities, called strangeness and parity, that are usually conserved, but not in those comparatively slow processes like β-decay and the transformations of the strange particles, processes that take millions of times longer than electromagnetic transitions liberating the same energy. In those transformations there is, in the theoretician's parlance, weak interaction between the initial and the final state.

Strange particles are always produced two at a time; e.g. when protons are bombarded with negative pions one does not observe the production of Λ^0-hyperons unless the energy of the pions is high enough to allow the simultaneous formation of a neutral K-meson, i.e. the process $p^+ + \pi^- \rightarrow \Lambda^0 + K^0$. Apparently, the simpler process $p^+ + \pi^- \rightarrow \Lambda^0$ is not possible, though allowed by our usual conservation laws. Yet the inverse process $\Lambda^0 \rightarrow p^+ + \pi^-$ does take place; but it is a slow one (about 10^{-10}sec mean life), with weak interaction between the initial and the final state.

Strangeness and parity

These facts, and many others, can be accounted for if we assume that strange particles possess a special kind of charge, for which the rather facetious name 'strangeness' has been adopted. If we ascribe one unit of strangeness to the positive and neutral K-mesons, a negative unit to the lambda- and sigma-hyperons, and two negative units to the xi-hyperons, we find that all those production processes that conserve strangeness are observed and all others are not.

But when these strange particles decay—a weak-interaction process—strangeness seems to be of no account; it is as if it had leaked away during the long time the particle had waited before decaying. The idea of strangeness has been put into mathematical form and has explained and even predicted a good many facts; but what its physical nature is we do not know.

Parity, on the other hand, has been known for a long time, and its conservation had never been doubted until 1956. It is a quantity that can be computed from the wave function of a quantum-mechanical system and that takes the two values of $+1$ or -1; we say the system has either even or odd parity. If the system transforms itself in any way, the parity must remain unchanged provided that the laws that govern the transformation make no distinction between left and right; that proviso was thought to be self-evident. But in 1956 it was found that the same kind of K-mesons could break up in two alternative ways, into a particle system of either odd or even parity; hence parity could not be conserved in both kinds of decay.

Once the conservation of parity was doubted, other tests were made and phenomena were found that distinguished between left and right: for instance, neutrinos were found to spin always anticlockwise (as seen from behind) while antineutrinos spin clockwise, and other particles (and antiparticles) emitted through weak interactions have the same tendency, although less complete. Does that make the universe unsymmetrical? Not if it contains antigalaxies; any experiment that defines a right-handed screw for us would define a left-handed screw if performed with antimatter. So the questions of space symmetry and charge symmetry have become linked through the weak interactions.

Summary

What use are these new particles? Neutrons are produced (and at once consumed) by the ton in atomic power stations, and for a time it looked as if the negative muon might help us build fusion reactors: it can pull two hydrogen nuclei together and make them fuse. But in its brief life it can do it only once or twice; so it cannot free enough energy to pay for the next muon.

Cancer therapy may soon employ π-mesons, which liberate most of their energy at the end of their path, causing almost no damage to overlaying tissues. Other possibilities, still undiscovered, may prove of practical importance, surprising even the science-fiction writers. But first we must properly understand the whole fascinating pattern of interrelations between these particles, a pattern that is only beginning to emerge.

INQUIRY INTO SANDWICH COURSES

An inquiry into the organization of sandwich courses in technical colleges and other colleges of further education is being undertaken by the National Advisory Council on Education for Industry and Commerce. A sub-committee has been set up 'to examine the organization of sandwich courses with a view to using college staff, equipment and accommodation and industrial training facilities to the best advantage; and in particular to consider "end-on" arrangements'.

The various methods by which practical experience in industry is combined with academic study in technical-college courses are being examined by the sub-committee. These methods include the 'end-on' system, in which two quite separate groups of students follow the same course but use the college alternately, one group being in college while the other is in industry.

52ND KELVIN LECTURE MEETING

Presentation of Institution Honours and Prizes for 1961

'MEDICAL ELECTRONICS' BY PROF. R. F. WOOLMER

THE Ordinary Meeting for the 52nd Kelvin Lecture was held in the Lecture Theatre at Savoy Place on the 27th April 1961 and was as usual very well attended. After the minutes of the Ordinary Meeting on the 6th April had been taken as read, the President, Sir Hamish D. MacLaren, welcomed the new Corporate members in the customary short ceremony.

New Honorary Member

The President then spoke about Lord Nelson of Stafford, Chairman of the English Electric group of companies, who was born in London in 1887. Before he was 18 years old, George Horatio Nelson had taken the diploma at the City and Guilds Technical College, where he had been one of the outstanding students of his year. He had been awarded the Mitchell Exhibition and a postgraduate Brush studentship and had become a premium pupil of the Brush Electrical Engineering Company. He had been appointed chief outside engineer of this company at 22.

Later, he had joined the British Westinghouse Company (afterwards Metropolitan-Vickers), and by 1920 he had established, and become manager of, their Sheffield works. His association with the English Electric Company had begun in 1930 when, in the days of economic depression, he had been appointed managing director. Three years later he became chairman.

The President continued:

'Even a brief summary such as this gives some idea of the rare combination of qualities which have enabled Lord Nelson to make such a distinctive personal contribution, not only to the development and success of his own organization but to the study and practice of engineering in this country and abroad. A brilliant engineer, a natural leader of men and a citizen of great public spirit, he has brought to the counsels of the numerous bodies to which he has given service the same capacity for wise and imaginative judgment and vision which led him to build, in the depths of the depression, the research and engineering laboratories at Stafford which bear his name.'

Lord Nelson, the President said, had joined The Institution in 1905, becoming an Associate Member in 1912 and a Member in 1918. He had been elected Chairman of the Sheffield Sub-Centre in 1926. He became an Ordinary Member of Council in 1949 and was elected a Vice-President in 1950 and President for the 1955–56 Session. The amount of time and sympathetic attention he had given to the affairs of The Institution, both before and after his presidential year, was an indication of the conscientious and energetic manner in which he fulfilled his extramural commitments.

He had achieved the rare distinction of serving as President both of this Institution and of The Institution of Mechanical Engineers. He had also been President of the Locomotive and Allied Manufacturers' Association, of the British Electrical and Allied Manufacturers' Association, and of the Federation of British Industries, on whose Grand Council he had served for the last 14 years. In May 1960, he had been installed as Prime Warden of the Goldsmiths' Company.

The President went on:

'Lord Nelson has always shown a deep and practical interest in engineering education; he is a Governor of Queen Mary College, University of London, and an Honorary Member and Fellow of the Imperial College of Science and Technology. He received the honorary degree of Doctor of Laws from the University of Manchester in 1957.'

He recalled Lord Nelson's many public activities, referring to his valuable advisory work during the war, quite apart from the output of aircraft, tanks and other equipment for our armed forces which had flowed from his group of companies and for which he had been responsible. From 1939 he had been a member of the Air Ministry's Heavy Bomber Committee; he had led the United Kingdom Tank Mission to North America in 1942; he had been, at various times, a member of the Reconstruction Joint Advisory Council, the Percy Committee on Higher Technological Education, and the Government Committee on Future Scientific Policy; and he had also served as chairman of the Government Census of Production Committee in 1945.

In recognition of his many public services, Lord Nelson had been created a knight in 1943, a baronet in 1955, and had been raised to the peerage in Her Majesty's New Year Honours of 1960.

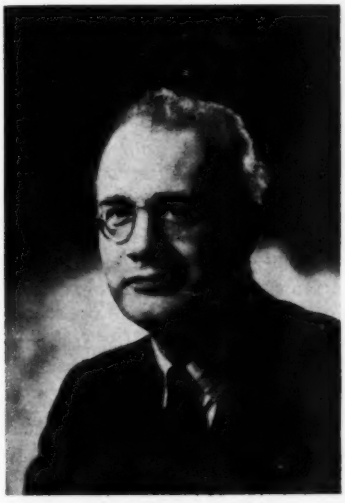
Then the President, amid applause, presented the vellum certificate of Honorary Membership to Lord Nelson of Stafford, who signed the Book of Honorary Members.

In replying, Lord Nelson modestly stated that he felt himself to be the bearer of only a small portion of what the President had said, and that he was deeply touched by the great honour that had been bestowed on him. Recalling his more than 50 years' membership of The Institution, he expressed his satisfaction and pride at the position of importance The Institution had achieved during this period.

'I do not mean to say', continued Lord Nelson, 'that that springs from my life; it springs from the good people who have been associated with me during that time and I pay great tribute to them. I am extremely fortunate in having been associated with electrical power engineering at the beginning of its epoch and in having been able to assist in the advances which have been referred to in the citation through various steps—through research, through development, and through the application of research and development to the benefit of man.'

Lord Nelson of Stafford, Honorary Member

Dr. Julius A. Stratton, Faraday Medallist



Prof. R. F. Woolmer, Kelvin Lecturer

He mentioned the contributions of electrical engineering to the welfare of Britain, including those of economizing production, improving quality and providing stable employment. He stressed the support he had received from his colleagues and that he hoped that 'all of them will share in their minds and feelings the same pride and pleasure which I take in having this great honour bestowed on me'.

In concluding, Lord Nelson expressed his gratitude to members of staff of The Institution and then paid tribute to his wife, who had inspired and supported him for so many years throughout all his activities.

Faraday Medallist

The President then came to the award of the Faraday Medal for 1961 to Dr. Julius A. Stratton, LL.D., the 11th President of the Massachusetts Institute of Technology (M.I.T.). Sir Hamish recounted that Dr. Stratton was born in Seattle, Washington, on the 18th May 1901. Having first studied for a year at the University of Washington, he transferred to that great centre of technological education with whose fortunes he had been so closely associated over the intervening 40 years, M.I.T.

After receiving the degree of Bachelor of Science there in 1923, he spent a year at the Universities of Grenoble and Toulouse, subsequently returning to M.I.T. for the Master of Science degree in 1925. In 1927 he received the degree of Doctor of Science in Mathematical Physics from the Technical College in Zürich, and he remained in Europe, on a travelling fellowship from M.I.T., studying principally at the Universities of Munich and Leipzig.

Dr. Stratton returned to M.I.T. in 1928 as Assistant Professor of Electrical Engineering. He became associated with the Department of Physics in 1930 and was appointed Professor of Physics in 1941, a post that he held for the following ten years. During this period, he was engaged in important basic research in the fields of radio and radar. When the Radiation Laboratory was established at M.I.T. in 1940, for the purpose of carrying out research in radar, Dr. Stratton was one of the first members of its staff. Two years later he became expert consultant in the Office of the Secretary of War.

As a result largely of his wartime activities, Dr. Stratton was widely known as an outstanding contributor to the theory of transmission-line, waveguide and antenna systems. His services had gained him the award of the Medal for Merit from the Secretary of War in 1946. He subsequently served as chairman of the Research and Development Board's Committee on Electronics and of the Naval Research Advisory Committee.

The President recalled that Dr. Stratton had been appointed the first director of the Research Laboratory of Electronics at M.I.T. in 1945 and had continued as such until he was appointed Provost of the Institute in 1949. He became Vice-President and a member of the Corporation in 1951 and was appointed Chancellor in 1956. He had been Acting President from November 1957 until January 1959, when he became President. During his years of administrative influence within M.I.T., he was notable, in particular, for having inspired the movement towards a thorough revision of the Institute's engineering undergraduate courses, involving a strengthening of their scientific foundations and the incorporation of studies in the humanities.

The President then said:

'At the present time, it is true to say that the Institute sets a high example of broadly conceived educational methods, and I would not hesitate to offer Dr. Stratton a full measure of credit for that achievement. It is a particularly happy chance that M.I.T. is this year commemorating the centenary of its foundation. Dr. Stratton has, in fact, crossed the Atlantic to receive the Faraday Medal immediately after the centennial celebrations in Cambridge, Massachusetts, at which we and our sister engineering institutions were fortunate in being represented by Sir Willis Jackson. May I confirm, Dr. Stratton, the very sincere congratulations on

this event which were presented on our behalf by Sir Willis earlier this month?'

The President briefly referred to Dr. Stratton's activities in public life, which had included serving as trustee for various civic, industrial and Governmental bodies. He concluded by mentioning Dr. Stratton's professional affiliations and the various honours that he had been awarded.

Amid warm applause, the President then presented the Faraday Medal for 1961, the 39th award, and certificate to Dr. Julius A. Stratton.

In his reply, Dr. Stratton said that everything he had accomplished in the field of science had stemmed from the work of Faraday and had been inspired by his example. He recalled his boyhood interest in electrical phenomena, starting with amateur radio and his days at sea as a radio operator.

This enthusiasm had led him to study electrical engineering at M.I.T., and little by little his interest had turned from the engineering aspects of electricity to the theoretical. He briefly described some of the promising horizons that lay ahead and referred to the challenge presented in the education of future scientists and engineers. He stressed that the engineers of the future must have not only complete mastery of the fundamentals of science and mathematics but also an understanding of social forces.

Dr. Stratton had relinquished his own work in electromagnetic theory with regret but looked forward to the contribution he could make to education.

Institution Prize-winners

The President then presented the Page Prize to Mr. J. Mildoon, the Goldup Prize to Mr. J. E. Eyres, the Henry Nimmo Prize to Mr. J. Foster, and Institution Prizes to 16 recipients.

In presenting the Goldup Prize, the President said:

'This is the first occasion on which there has been an award of the Goldup Prize. It was established with the help of a munificent donation by Messrs. Mullard in memory of a very recent President of The Institution, Mr. Tom Goldup, and it will be awarded now and in the future to the best of those candidates who obtain distinction in all the compulsory subjects of the final year of the Higher National Certificate course in electrical engineering, provided that these include an electronics or telecommunication subject.'

THE KELVIN LECTURE

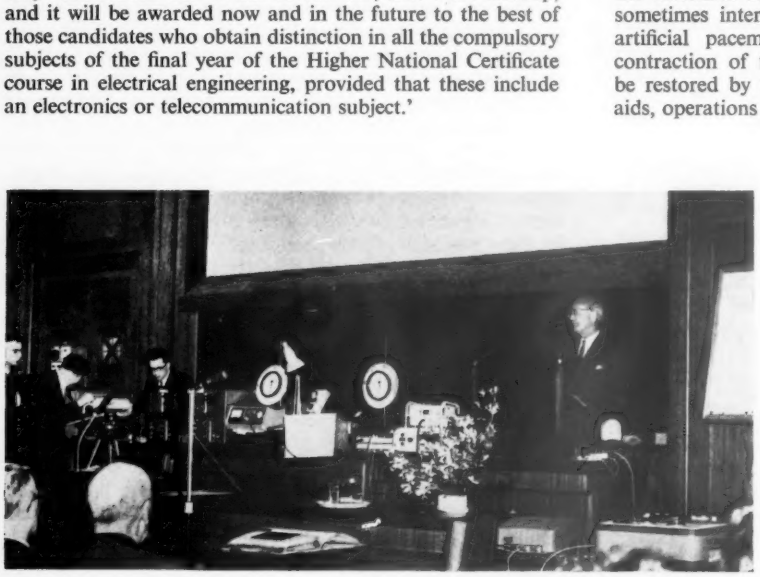
The President called on Prof. R. F. Woolmer, V.R.D., F.F.A.R.C.S., to deliver the 52nd Kelvin Lecture on 'Medical electronics'.

Natural control mechanisms

Prof. Woolmer introduced his subject by stating that many of the techniques of electrical engineering could be applied to medicine and biology. Nature in fact made use of devices, such as relays, servo-systems and computers, that were among the tools of the electrical engineer. The pressure transducers in the skin and in the ear, and the photocells in the retina, were examples of nature's effortless superiority in the manufacture of sensing devices; and, for compactness, economy of power consumption and reliability, man-made systems could not compete with the natural ones, though they were often superior in speed. The natural devices were backed by a development programme that had already been going for millions of years and that had the world for its working-space.

An example of a natural control mechanism was the regulation of breathing, which was achieved through a typical servo-system. The controlling parameter was the partial pressure of carbon dioxide in the blood. This was measured by a sensing device in a blood-vessel in the brain. The output was fed to the control centre nearby, where it was compared with a stored optimum. The resulting error signal was used to modulate the stream of impulses passing from the control centre to the motor organ—the muscles of respiration. Negative feedback from the motor organ to the control centre ensured smoothness of action.

The development by electrical engineers, working from first principles, of similar control systems had helped biologists and medical men to understand the natural ones, to realize how they might fail, and to undertake repairs or substitutions. Electrical engineering was thus making a major contribution to medicine and surgery and, in particular, to the newer operations on the heart and great vessels, which depended on an artificial heart-lung machine. During these operations the electrical conducting system that drives the heart was sometimes interfered with and had to be replaced by an artificial pacemaker. On other occasions, synchrony of contraction of the heart-muscle fibres was lost and had to be restored by the electric defibrillator. Without electronic aids, operations on the heart would be more hazardous.



Prof. Woolmer illustrates electronic presentation of biological data at the 52nd Kelvin Lecture

Measurement

Many bodily functions were measured by electrical means. Prof. Woolmer demonstrated the use of a television display to indicate the carbon dioxide content of an assistant's bloodstream; he caused her to breathe into a rubber bag, which reduced the oxygen and increased the CO_2 level. He said that the electrocardiograph, the electroencephalograph and the electromyograph provided information about the activity of the heart, the brain and the muscles respectively, and action potentials from discharging neurones revealed the patterns of activity in the nervous system.

In these instances the signal was already in electrical form and merely required amplification to work an indicating or recording device. Biological potentials were small, however, and picking them up from the surface involved much attenuation and electrical noise, so that amplifiers needed careful design.

The Lecturer played a tape recording that dramatically illustrated the sounds of various heart abnormalities, and then showed these abnormalities on a television screen. He also demonstrated the recording of blood pressure using visual and auditory presentations.

He said that other types of biological activity had to be converted into electrical form to take advantage of amplification, telemetering, recording, frequency analysis and integration, which electrical engineering was so well fitted to provide. A number of transducers had been developed for these conversions. The most important among these were pressure and flow transducers, to be applied to the respiratory and cardiovascular systems. Whenever possible, information about events inside the body was gained by electrodes or transducers applied to the surface, or by such methods as X-rays, ultrasound and endoscopes (which were examples of 'non-destructive testing').

However, it was sometimes essential to introduce sensing devices into the interior of the body. An example was the introduction of a tube, through a blood-vessel in the arm, into the interior of the heart. By means of a suitable transducer, the pressures in the chambers of the heart could thus be measured and anomalies of structure and function could be revealed.

Other electrical applications

Because electrical engineering techniques were so well adapted to measurement and control, they had many important uses outside the operating room. They were being increasingly incorporated in devices to help the physically disabled. Transistors made these devices portable and independent of mains. Portable measuring devices might also be used in field studies of the behaviour of the human or animal body. Information might be stored in them or telemetered immediately to a central station.

At one point, the Lecturer startled the audience by firing a spark into a plastic bag filled with an anaesthetic-gas mixture, causing a loud explosion. This, he said, illustrated the danger of bringing electrical apparatus near such gases.

Prof. Woolmer stated that most branches of biological research now made use of electronic methods. The cathode-ray oscillograph was displacing the kymograph and the smoked drum (though these still had their uses), and electrical methods of data retrieval, storage and display, together with analogue and digital computers, were greatly increasing the effectiveness of experimental methods.

In teaching, closed-circuit television could now enable large groups of students to see details of surgical operations and demonstrations of micro-techniques. Electrical analogues of biological systems could be used to explain or predict their behaviour. A patient-simulator for the teaching of anaesthesia—comparable to a flight-training simulator—was a possibility.

Prof. Woolmer concluded the Lecture by stating that the field of overlap between biology and medicine on the one hand and electrical engineering on the other was a fruitful and expanding one.

A vote of thanks to Prof. Woolmer was proposed by Sir Gordon Radley, who congratulated the Lecturer on the excellent preparation and delivery of his material. He said that, although the Lecturer was a specialist in anaesthetics, the one thing he had not done during the course of the Lecture was to put his audience to sleep. He ended by proposing that the vote of thanks should include Prof. Woolmer's team of assistants.

The vote of thanks was carried by acclamation, whereupon the President declared the meeting closed. The Lecture will be published in full in the *Proceedings* of The Institution.

RECENT NUCLEAR DEVELOPMENTS

PHYSICISTS of the Atomic Weapons Research Establishment, Aldermaston, in collaboration with scientists of the Clarendon Laboratory, Oxford, have discovered a new carbon isotope of mass 16. A carbon14 target was bombarded with a beam of 6 MeV tritons (ions of tritium, or super-heavy hydrogen) from the Aldermaston Van de Graaff accelerator.

It was observed that, in some cases, the force of the collision was sufficiently great to split the triton into its constituents of one proton and two neutrons; the two neutrons were captured by the carbon14 to form the new isotope, carbon16. By making precise measurements on the emitted protons, it was determined that the mass of the new isotope was 16·014702 atomic mass units. Its half-life was found to be 0·74 sec, even shorter than that of carbon15.

Reactor Group

The new Reactor Group of the U.K.A.E.A. assumed central control of the largest single organization in the world for the design and development of nuclear reactors when it became operative at the beginning of April 1961. Its facilities are located at Dounreay, Windscale and Winfrith.

The Winfrith site has the greatest diversity of work in progress, and most of the facilities are contained in three large buildings. The first houses three reactors, exponential stacks, a differentially-heated graphite assembly, and the cold fine structure experiment; a fourth reactor has been moved from Harwell and is being reassembled there. The second building contains two reactors and will eventually hold another. The third houses a high-temperature reactor, and its facilities are being used for the construction of the international Dragon reactor.

At Windscale, there are two reactors: one, Hero, is scheduled to begin operation this year, while the other, the advanced gas-cooled reactor, is nearing completion. There are also two exponential stacks at this site.

The Dounreay establishment's prime concern is work with the fast breeder reactor. It houses also the Dounreay materials-testing reactor, as well as six critical assemblies.

RAILWAY MODERNIZATION CONFERENCE

THERE were over 1200 registered members for the conference on railway modernization arranged by the three senior engineering institutions on the 3rd and 4th May 1961 at The Institution of Civil Engineers in London. In opening the conference, Sir Herbert Manzoni, President of The Institution of Civil Engineers, asked if this were a protest at the injustices so often offered to the Railways or a vote of confidence in a public service to which we should all give every possible support. He was glad to welcome over 100 oversea delegates.

In this review it is naturally impossible to give more than the merest indication of the content of the papers and discussion, which will be published in due course by The Institution of Civil Engineers.

Engineering aspects of the Modernization Plan

In presenting his paper giving a general review of the engineering aspects of the Railway Modernization Plan, Mr. R. C. Bond, Technical Adviser to the British Transport Commission, stressed that its aims were as valid today as in 1954. The main aim was broadly to exploit the great natural advantage of the railways as bulk transporters of passengers and goods by a purposeful concentration on organizing and equipping them where they could be more efficient than other forms of transport. This needed close collaboration between all departments and an understanding of the other man's problems. It was perhaps in recognition of this vital fact that the three institutions had met to discuss this important combined engineering operation.

The Plan provided for the progressive replacement of steam locomotives by electric and Diesel traction for a variety of reasons: some economic, some technical and some social. Mr. Bond stressed the extent of the changes already made: in 1947, only 904 miles out of a total of 19600 were electrified and there were seven main-line Diesels. The outward and visible signs of modernization were to be seen in all parts of the country to a rapidly increasing extent. The last steam locomotive had been built for British Railways, and it was more than 12 months since the train mileage run by electric and Diesel traction combined exceeded that run by steam.

But much remained to be completed before the full economic results from new equipment and pattern of services would be felt. The progress of the many separate but interdependent works, which together constituted the Plan, was under continuous review. The Plan as a whole had been subjected on more than one occasion to a critical reappraisal in the light of technical and economic trends that had emerged since 1955. It had been unnecessary to change the pattern or objectives in any important respect.

The contribution of civil engineering

Mr. M. G. R. Smith, Chief Civil Engineer, Western Region, British Railways, then presented his paper 'The contribution of civil engineering'. He observed how much more impressive the civil engineering results would appear if they could be seen concentrated in one piece of line. He showed a film, 'Progress review of civil engineering', illustrating how 300ft lengths of rail and track could now be laid as though they were cables and that the method was being extended to 900ft lengths.

Throughout the railways, improved permanent way was being laid down; bridges were being raised for electrification; new stations, marshalling yards, goods stations and offices were being built. All this was backed by research programmes to ensure that everything was done in the best way at the lowest cost. Above all, he pleaded for at least a five-year plan.

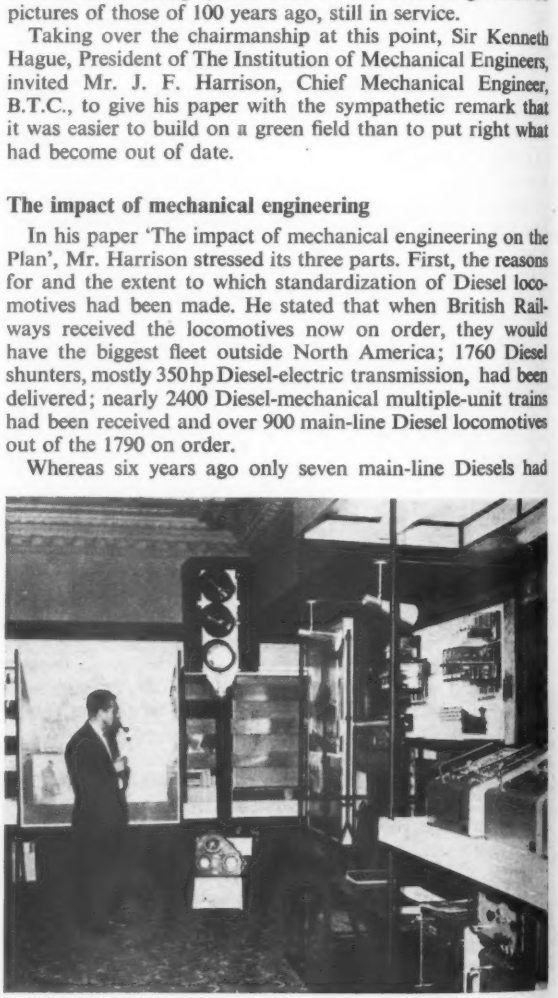
The discussion was opened by Mr. V. A. M. Robertson. He was followed by Mr. Karnail Singh, Chairman of the Indian Railways Board. Mr. Singh pleaded for a new title, such as was used in India for a plan of the same breadth, now in its stride, and having many similar features: they called their plan *Vicāsh*—enlightened development. He hoped to have proof of the betterments that would be achieved and of the steps by which any difficulties that had arisen had been overcome. Mr. Smith had shown some slides of the newer bridges, and Mr. P. S. A. Berridge showed pictures of those of 100 years ago, still in service.

Taking over the chairmanship at this point, Sir Kenneth Hague, President of The Institution of Mechanical Engineers, invited Mr. J. F. Harrison, Chief Mechanical Engineer, B.T.C., to give his paper with the sympathetic remark that it was easier to build on a green field than to put right what had become out of date.

The impact of mechanical engineering

In his paper 'The impact of mechanical engineering on the Plan', Mr. Harrison stressed its three parts. First, the reasons for and the extent to which standardization of Diesel locomotives had been made. He stated that when British Railways received the locomotives now on order, they would have the biggest fleet outside North America; 1760 Diesel shunters, mostly 350hp Diesel-electric transmission, had been delivered; nearly 2400 Diesel-mechanical multiple-unit trains had been received and over 900 main-line Diesel locomotives out of the 1790 on order.

Whereas six years ago only seven main-line Diesels had



Part of the exhibition of the British Transport Commission at the conference

been in service, today less than one-third of the passenger trains were steam-hauled. So far, there was no clear advantage in favour of hydraulic or electric transmission, nor in favour of high-speed or of medium-speed Diesel engines. Electric heating of passenger stock was the policy for the future, and stock was rapidly being equipped for dual steam and electric heating. Commenting on the improvement in failure rate, Mr. Harrison remarked that far too many failures were due to avoidable minor and random defects of auxiliaries.

The second part of Mr. Harrison's paper dealt with some special problems, such as braking, riding, automatic couplers and use of light-weight coaches; and the third part with the impact of new types of locomotive on railway workshops and traffic possibilities.

The success of the Modernization Plan depended not only on the provision of motive power more powerful, more easily and comfortably operated, and with a much greater potential availability and reliability than steam, along with reduced maintenance costs per mile, but also on the ability of the operator to make use of the improved availability by an entirely new conception of locomotive diagramming. When it was remembered that today an electric locomotive with regenerative or rheostatic braking could work for six weeks or more without even visiting a maintenance depot, the potentialities of usability were very evident.

This paper was followed by a lively discussion in which 16 took part, including M. Lamiral, of the Société Nationale des Chemins de Fer Français, who reported some disappointment in their experiments with disc brakes which Mr. Harrison had said showed promise. Mr. F. Kurz of the Southern Pacific Railway said, however, that non-ferrous brake blocks were now fitted to all passenger cars. Several speakers, including Mr. A. W. Manser and Mr. W. J. A. Sykes, supported Mr. Harrison's views on the importance of eradicating, possibly by more realistic accelerated tests, minor defects. Mr. Manser questioned whether on some, at least, of British Railways duties there was not a better case for light-weight stock than Mr. Harrison had indicated. Mr. S. Wise was critical of the continued use of small unbraked wagons.

The session concluded with two films: the first, 'Second report on modernization' by British Transport Films, gave a comprehensive picture of what is going on, while the second dealt more particularly with the civil engineering background to modernization.

Electric traction

Sir Hamish D. MacLaren, President of The Institution, opened the third session and immediately introduced Mr.

Sir Hamish D. MacLaren presiding during the second day of the conference

Mr. S. B. Warder giving his paper

S. B. Warder, Chief Electrical Engineer, B.T.C. Much had happened, Mr. Warder said, since his paper 'Electric traction in the Modernization Plan' was written a year ago—many good things and some not so good. Having mentioned the successful development of the third-rail system by the old Southern Railway and its continuance by the Southern Region, and the very good results achieved on the Eastern Region with the 1500V overhead system, accepted as the standard when the Modernization Plan was made, he explained why he had, with the support of the industry, recommended the 50c/s 25kV a.c. system as the future standard.

He explained why it was necessary to use the dual voltage 25/6·25kV, which brought a novel element into the scheme. The contractors concerned had been given considerable freedom to develop distinctive ways of fulfilling the stipulated requirements, and the results had been proved by such trial running as circumstances allowed.

The equipment had behaved well, but, when put to the final proof in full public service, some components of some equipment had failed. These failures had received much publicity, but he could say little about them as they were the subject of an inquiry by Brig. C. A. Langley, Chief Inspecting Officer for Railways of the Ministry of Transport. It could be said that the failures of a few components had added much new fundamental knowledge and had not shaken the Commission's confidence that their original decision about the system had been right. Mr. Warder concluded by referring to the welcome decision to complete the London Midland Region electrification from Manchester and Liverpool to Euston. A.C. multiple-unit trains had already run 7500000 miles.

Courage and the a.c. system

Opening the discussion, Brig. Langley complimented Mr. Warder on his courage in recommending the a.c. system and on the directness with which he had now described what had happened. He said that he had nearly completed his second interim report into the troubles in Glasgow and on certain equipment on the Eastern Region; he felt that it would be inappropriate to comment on the matters under investigation, but he would say that the modified units now undergoing trials in Glasgow were running well. He endorsed Mr. Warder's opinion that the conversion of the Shenfield–Southend line was a very fine technical achievement that had not received the publicity it deserved.

Referring to tests at Colchester designed to evaluate the safety of the system if rules were obeyed and the danger if they were not obeyed, he asked Mr. Warder if tests now being made gave hope of a reduction in the necessary clearances for 25kV.

Mr. H. B. Calverley confirmed that the contractors

welcomed the decision on the system and described a new development not mentioned in the paper, namely the use of transductor control on a locomotive equipped with silicon rectifiers and a rheostatic brake, and claimed as advantages better adhesion and efficiency with practically notchless control, free from any arcing at main contacts. Mr. E. L. E. Wheatcroft confirmed that, in his view, the troubles that had developed would be overcome, and so did Mr. C. C. Inglis, who also recalled that four years ago improvability had been claimed as one of the main reasons for adopting the new system. The use of solid-state devices was one such aspect that B.T.C. research was investigating.

Mr. D. P. Sayers noted that B.T.C. were one of the two largest users of electricity: they now used 430 MW and 1500 million kWh per year with a load factor of 41%, and in a few years' time, when the main-line scheme with a load factor of 67% came into being, they would be using 2300 million kWh with a load factor of 46%. Their bill was about £8 million per year. If the load factor could be improved by running more freight at night, they could reasonably expect better terms; he asked what were the prospects in this direction and what proportion was the cost of current in the total cost of running a railway.

No talk of failure

In the ensuing discussion, Mr. J. R. Pugh gave particulars of improved glass-fibre techniques for insulation, particularly where light weight was dynamically important, and stressed the correctness of the British view that compound catenary was well worth while. Mr. J. A. Broughall, debarred from talking of failures, listed the successes achieved, distinguishing between those that were complete and those marred only by small, easily avoidable defects, just as infuriating to the traffic department.

Mr. J. R. Harding recalled Sir Philip Dawson's pioneering work on the Brighton line and likened the Shenfield conversion to the change from broad to standard (4ft 8½in.) gauge. Mr. W. A. MacNeill thought that recent advances in porcelain insulators had secured them a place in the future, and Dr. F. T. Barwell gave particulars of research in progress on the use of solid-state devices.

The Hon. G. E. Boscawen thought that the good results of much work and research had been understated, but asked why more use was not made of dead sections at difficult bridges. The discussion was concluded by Mr. Karnail Singh, who gave a vivid account of the circumstances in which, in 1957, he had reached the same decision as the B.T.C. about the system to be used in electrifying Indian Railways. He did not regret that decision and thought the Indian achievement of 200 miles per year, to be increased to 400 miles per year, was of the same order as that of B.T.C., and he welcomed the possibility of being in a position to use British help, which he had not been able to have four years before.

Mr. Warder briefly replied. The tests with reduced clearance were, so far, favourable. The cost-of-current element was about one-third of the net cost of electric-train movement but perhaps less than 10% of the whole cost of running a complete railway organization.

Signal engineering and telecommunication

In presenting his paper, Mr. J. F. H. Tyler, Chief Signal and Telecommunications Engineer, Southern Region, British Railways, stressed that three varieties of equipment existed and that there was no textbook of railway signalling nor any university course on the subject. The new works of the Plan, in addition to schemes in hand for normal economies and increased security, had presented the signal engineer with a formidable task. He described the main types of signal equipment and the bad effect of diversity of train speed on line capacity.

The several arrangements possible to avoid interference with 50c/s traction were dealt with at some length. This was also considered in a section dealing with telecommunication circuits, which included maps showing the railway trunk network now under construction for subscriber dialling throughout all Regions. The cables would either be coaxial or carrier quad, with a microwave link between York, Darlington and Newcastle. He concluded with an account of the signal engineer's interest in the control of wagon movements through marshalling yards (now largely using electronic techniques), of lifting-barriers at level crossings, and of the automatic warning system for assisting drivers in obeying signals.

In opening the discussion, Mr. A. W. Woodbridge, Chief Signal and Telecommunications Engineer, B.T.C., remarked that the continued existence of different signal systems was not a good thing. He indicated the steps being taken to attain a measure of standardization and to use miniature relays and solid-state switching techniques. Good signalling not only improved security and time-keeping but permitted better use of the expensive locomotives now being employed. The signal engineers' worst fears about the effects of a.c. electrification had not been realized.

Mr. De Heer, of the Netherlands Railways, described the extensive use of automatic level-crossing barriers in Holland, of which several hundred had been installed. The discussion was concluded by Mr. N. J. B. Alexander, who was very critical of the accuracy of selection of marshalling-yard equipment.

Transport and argument

Mr. J. Ratter, Member of the British Transport Commission, summed up the conference, stressing that it had been a very typical illustration of H.R.H. The Duke of Edinburgh's dictum in the same hall recently that the word 'transport' in this country was bound to raise an argument. He had been particularly struck by the plain words of Mr. Alexander about marshalling yards and of Mr. Wise about wagons. The Commission were not complacent about these things, nor about its very evident skeleton of the annual deficit. The Modernization Plan was a case of building for the future, and the engineer of today had the responsibility for seeing that the foundations of the railways of the future were as well laid as those put down by our predecessors of 100 years ago.

As regards suburban-passenger trains, he did not think anyone seriously questioned that the railway was the only effective way of saving mankind from the motor car. He gave examples of the earning capacity of electrified lines, varying from 40% to 100% additional receipts in a few weeks or months. After reviewing broadly all kinds of railway activity and finding much hope for the future, he concluded that, having chosen to take some risks rather than postpone improvements, the worst of our troubles were now behind us. 'The future of the railways', he said, 'is a challenge, but with faith it is an exhilarating challenge. The foundations have been laid. I think we can say that we have reached the end of the beginning.'

J. A. B.

LETTERS TO THE EDITOR

Voting procedure..... G. I. Thomas, B.SC., MEMBER
Watts and vars.....Prof. R. O. Kapp, B.SC.(ENG.), MEMBER
Industrial noise hazards and their prevention..E. A. Payne, ASSOCIATE
Engineering writing and speech.....D. G. Chapman, ASSOCIATE MEMBER

VOTING PROCEDURE

Dear Sir—In elections to the Committees and Council of The Institution, the retiring body puts forward a list of suitable nominations for all the vacancies, and there may be in addition one or more nominations from other members. Voting is carried out by striking out names from the list of candidates so as to leave a number equal to the number of vacancies. It is desirable, if committees are not to be self-perpetuating, that any unofficial candidate of reasonable standing should have a fair chance of success, but it appears that the present method of voting makes the chances very poor when the unofficial candidates are few in relation to the vacancies. This is because every vote for the unofficial candidate is accompanied willy-nilly by several for the official list.

For example, a typical case in elections to a local Centre Committee would be an official list of four candidates for four vacancies, and one unofficial candidate. Each vote for the unofficial candidate is, of course, an adverse vote for one or other of the official candidates. If the adverse votes were evenly distributed over the four official candidates, the unofficial candidate would require to be supported by over 80% of the voters; if an official candidate were to attract to himself half the adverse votes, the unofficial candidate would still require 67% of possible votes; while if all the adverse votes were concentrated on one official candidate, just over 50% would be needed. It is very unlikely that in such an election an unofficial candidate has ever succeeded.

Elections become more open as the number of unofficial candidates increases, and if it equals the number of vacancies those who favour the unofficial block have an equal chance with the supporters of the official block. This situation is often approached in Council elections, and the number of successful unofficial candidates is correspondingly quite significant.

I suggest that voters should be able to exercise their discretion freely and not be obliged to spend any of their votes on candidates they may not wish to support; they should be able to vote by leaving on their list any number of names from one up to the total of vacancies; and this system should apply to all Committee and Council elections.—Yours faithfully,

G. I. THOMAS
Merkland
20 Lennox Row
Edinburgh 5

20th April 1961

[The present method of enumerating the votes in ballots for elections to the Council and the Section and Centre Committees is as follows. In those categories in which there are more candidates than vacancies, each candidate whose name is not deleted by the voter receives one vote for each valid ballot paper returned. On completion of the scrutiny of the ballot papers, the scrutineers count the total number of votes received by each candidate; if there are, for instance, four vacancies in the category concerned, those candidates with the four largest total numbers of votes are deemed to have been elected. The relevant Bye-law dealing with elections to the Council (Bye-law 51) stipulates that 'each Corporate Member or Associate voting shall delete sufficient names to reduce the number of names on the ballot paper to the number to be elected to the respective offices'.—Editor]

WATTS AND VARS

Dear Sir—There is strong support, particularly among physicists, for the claim that volt-amperes, vars and watts are all equal to each other. This is the official view of the International Organization for Standardization.

Its recommendations on quantities and units of electricity and magnetism, at present still in draft form, contain the statement: 1 VA = 1 W; 1 var = 1 W. This statement is said to be the consequence of applying theory of dimensions to the definition of units, and to be justified by the fact that volt-amperes, vars and watts all have the same dimensions.

The document containing this statement has been circulated to all National Committees as well as to many international scientific bodies. The statement has been endorsed by nearly all of them, though not by the British National Committee.

The following questions arise. Is one to conclude:

(1) that those are deficient in scientific understanding who deny that one is any more justified in writing 1 W = 1 var than one is in writing 1 yard = 1 metre?
(2) that there is something very wrong with a theory of dimensions that leads the distinguished scientists who represent their countries on the I.S.O. to claim that it is right without any conversion factor (tan ϕ) to write 1 W = 1 var (or at least 1 var = 1 W)?

Comments would be interesting.—Yours faithfully,

REGINALD O. KAPP
Kennedy and Donkin
12 Caxton Street
London S.W.1

26th April 1961

INDUSTRIAL NOISE HAZARDS AND THEIR PREVENTION

Dear Sir—After reading the article by Dr. D. E. Hickish in the March 1961 *Journal*, p. 151, I am wondering whether enough thought has been given to the *advantage* of noise in industry.

To those destined to work with people who make irritating noises with their noses and pipes or with typists who ceaselessly chatter, the sound of machinery or 'Music while you

work' is a merciful relief and actually *increases* industrial efficiency, apart from the benefit to the health of the individuals concerned.—Yours faithfully,

E. A. PAYNE
Little Baddow
26th April 1961 Chelmsford, Essex

[Dr. Hickish writes: I am indebted to Mr. Payne for a graphic illustration of the annoyance resulting from the type of noise that I described as 'meaningful or intermittent'. The masking of such sounds is no doubt desirable on aesthetic grounds alone!

It is fairly generally accepted that music, provided that its nature, timing and intensity are appropriate, can be beneficial to performance and output. There are, however, instances that I have encountered where an existing noise problem has been aggravated by the addition of music. A background sound pressure level of 92dB (ref. 0·0002 dyne/cm^2) in one case was raised to 95dB when the music was relayed.]

ENGINEERING WRITING AND SPEECH

Dear Sir—I am dismayed at the apparent decline in quality of the meetings being held in London, where some excellent material is being disseminated in a manner that is not calculated to add to the dignity, interest or importance of the subjects.

At a recent well attended meeting on the transmission of information, the 'transmitter' was constantly on the move, so that 'data' were being transmitted via the sound-reinforcement equipment in random blocks, which left much to be desired by the 'receivers'.

Unfortunately, this sort of thing is, in my experience, becoming the rule rather than the exception; and one is forced to the conclusion that, whereas our authors are, without exception, the most knowledgeable people concerning their subject, there appears to be an abysmal ignorance concerning the basic principles of oratory and, sad to say, many of them, judging by the halts and pauses, have only a nodding acquaintance with the text of their paper.

Let me hasten to add that those gentlemen who have delivered the Faraday Lectures are monumental exceptions to this sad state of affairs, and they and His Royal Highness The Duke of Edinburgh, whose delivery of the recent Graham Clark Lecture was beyond all reproach, have shown themselves to be masters of the art of putting over technical information in such a manner that their subjects were made to live in the minds of the hearers.

The Royal Institution has done great service by publishing Michael Faraday's 'Advice to a lecturer'. Could not our Papers Committee go one better by ensuring, by means of rehearsal if necessary, that the dignity of our worthy Institution be not lost through poor delivery?

In fairness to some speakers, I would suggest that the placing of microphones and loudspeakers, in the systems provided at Savoy Place, is hardly suitable for the lecturer who wishes to make adequate use of a blackboard and screen, and attention to this matter would go a long way towards rectifying the distractions described above.—Yours faithfully,

D. G. CHAPMAN
11 Stuart Close
28th April 1961 Farnborough, Hants

Institution Council meeting on the 18th May 1961

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 18th May 1961 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, since some items are to be the subject of further discussion by the Council.

Membership

The Council gave their final confirmation of the election of those candidates whose names had been published with the April 1961 *Journal*, to become effective from the 1st June 1961. Taking these into account, the total membership at that date was 47761.

Committee constitutions

The Council acceded to a request from the Supply Section Committee for permission to increase the number of ordinary members of the Committee from 12 to 14.

A request from the North-Eastern Centre Committee was also granted, that the number of members of the Committee of the Measurement and Electronics Group of the Centre be increased from six to eight by modifying the Centre rules. While for the North-Eastern Centre Group this increase would be made mandatory in the Centre rules, any future revision of the general rules covering Group Committees in local Centres would provide for eight being the maximum number.

Joint Committees for National Certificates and Diplomas in electrical engineering

The Council received with interest the Annual Reports for the 1959–60 Session of the Joint Committees for National Certificates and Diplomas in electrical engineering for England and Wales, Scotland and Northern Ireland.

Symbols and abbreviations

On behalf of the Chairman of the Examinations Committee, Mr. Donkin introduced a proof of the revised booklet 'Symbols and abbreviations recommended for use in electrical engineering courses'. This revision had been carried out with the assistance of the British Standards Institution and the Editor-in-Chief of the *Proceedings*, and the text now recommended represented to some extent a compromise between

the recommendations of the B.S.I. and the editorial practice adopted in the *Proceedings*. The Council approved the booklet for publication.

Election of new Members of Council

It was reported that, since no nominations had been received from members of The Institution for election to the Council for the 1961–62 Session, the nominees of the Council were deemed to be duly elected in accordance with the provisions of Bye-law 51 (see April 1961 *Journal*, p. 253).

The election of Dr. R. L. Smith-Rose as a Vice-President created a casual vacancy among the Ordinary Members of Council and, in accordance with custom, the President was given authority to make a suitable appointment for the unexpired part of Dr. Smith-Rose's term of office as an Ordinary Member of Council. The President announced that he had pleasure in appointing Mr. G. Millington, M.A., B.SC., MEMBER, to fill the casual vacancy, and this received the unanimous support of the Council.

Tees-Side Graduate and Student Section

The Council approved a recommendation of the North-Eastern Centre Committee that the Tees-Side Graduate and Student Section, which had so far operated semi-officially, should now be placed on a permanent basis. There would be sufficient support for the Section's activities, since the membership would be about 90 and there had been an average attendance of about 25 at meetings.

Electronics engineers

The General Purposes Committee, in the course of a study of the scopes of the present specialized Sections of The Institution and The Institution's learned-society facilities in general, had discussed the possibility of improving the manner in which electronics interests were catered for in various aspects of The Institution's life. The Committee wished to propose two interim measures now; and the following Resolution, which was moved by Sir Willis Jackson and seconded by Mr. L. Drucquer, was passed unanimously:

The Council, recognizing the significance of electronics interests in electrical engineering, resolve
(1) that steps should be taken to ensure, as far as practicable, equal representation on the Council and Council committees* of the interests generally identified as 'electronics' and 'power';
(2) that, in order to ensure that no obstacle lies in the path of any suitably qualified person being admitted to membership of The Institution, the Education and Training and the Examinations Committees be asked to review again the examination syllabuses and training regulations to ensure that they are appropriate for those (in particular, electronics engineers) who, though of recognizable professional level, are not adequately provided for under the present regulations.

Svenska Teknologforeningen—centenary celebrations

The Swedish Engineering Institution will be celebrating its centenary this year, and the four British engineering institutions had received invitations to be represented. It was agreed that a single representative of the British institutions should be appointed to present a joint illuminated address.

Advertisements

The Papers Committee, at their meeting that morning, had agreed to recommend to the Council that the ban on advertisements of foreign goods in Institution publications be removed. Not only was Great Britain becoming increasingly involved in European trade but it was felt that discrimination of this sort was wrong in principle; increased advertising revenue would also follow. After discussion, the Council accepted the Committee's recommendation, but it was agreed that care should be exercised when considering the publication of advertisements of foreign equipment, particularly domestic, that contravened British wiring rules or practice.

* It is the intention that this should be done, in the case of the Council committees, during the selection of committees procedure for next session and, in the case of the Council, as soon as possible thereafter

The 'Dame Caroline Haslett', a 2700 ton motor collier owned by the Central Electricity Generating Board, ready to begin laying the cross-Channel power cable

CROSS-CHANNEL POWER LINK

OPERATIONS in connection with the undersea laying of the British half of the cross-Channel power cable began at the end of May 1961; the French half has already been laid. With the link joined and operative, 160 MW of power will be transferable between the two countries at 200 kV d.c. and 800 A; it is expected that this will be accomplished by December 1961.

This reserve of power will accommodate the different periods at which the electricity demands in France and Britain are greatest, and the different generating methods in use in the two countries. Thus, at times of peak demand, Britain will have available the power that would otherwise have had to be generated from additional plant and at greater expense than the British share of the cost of the cross-Channel link.

The link is about 38 miles long and uses an impregnated-paper-insulated solid-type cable. Each cable operates respectively at 100 kV positive and 100 kV negative to earth. It will connect convertor stations at Lydd, in Kent, and at Echinghen, east of Boulogne. At Lydd, connection will be made to the British Grid by a 275 kV line to Canterbury; at Echinghen, 225 kV connections will go out to Amiens and Holque.

East and West explored by Civils and Mechanicals

Visits of the Presidents of the I.C.E. and the I.M.E. to the West Indies and the Far East

In accordance with the joint policy of the three senior engineering institutions that oversea Groups should be visited at roughly three-year intervals, recently Sir Herbert Manzoni, President of The Institution of Civil Engineers, and Mr. Alexander McDonald, Secretary, travelled to the West Indies and Prof. Owen A. Saunders, then President of The Institution of Mechanical Engineers, and Mr. K. H. Platt, Secretary designate, visited the Far East. The impressions of the two Presidents are given in these short reports.

CIVIL ENGINEERS

Sir Herbert Manzoni and Mr. A. McDonald travelled the Caribbean area and British Guiana between the 22nd February and the 19th March 1961. They went to Jamaica, Trinidad, British Guiana, Barbados and the Bahamas. Meetings were held with the Joint and Professional Groups.

The President and Secretary of the I.C.E. inspecting the bulk-sugar-handling equipment in Barbados Harbour

Sir Herbert Manzoni and Mr. A. McDonald are third and fourth from the left respectively

Visits to Jamaica and Trinidad

In Jamaica, visits were paid to colleges, factories, a drainage and irrigation project, the airport and many other places. Calls were paid on the Governor, Prime Minister and other dignitaries, both civil and academic.

Among the many subjects discussed, probably the most important was the training of technicians, a problem common to all the Caribbean territories. Other matters discussed included the use of the international general conditions of contract and the problems of delays in plant deliveries and inadequate servicing.

In Trinidad, visits followed a similar pattern to those in Jamaica. A sugar plantation and modern factory were visited, as were a highway over swamp-land, an hotel being built on a steep slope with awkward foundation problems, etc. Perhaps the most interesting visit was to the off-shore oil drilling at Point Fortin. The famous pitch lake was viewed from the air and seemed disappointingly small.

Calls were paid on the Deputy Governor-General of the Federation, the Governor of Trinidad, several Government ministers, academic staff of University College and local dignitaries. Subjects common to most of the discussions were the poor quality of craftsmen; the lack of television; and the inadequate servicing for British equipment, vehicles, etc.

Practical training and experience should, it was felt, be related to the economic conditions of the country, and some concern was felt about the requirements of the Mechanicals and Electricals for 'heavy' engineering training, which is not available in such territories. The importance of technician training is properly appreciated, and too much emphasis should not be placed on routes to professional grades through the technical colleges.

Similar problems in British Guiana

In British Guiana, calls were paid on the Prime Minister and the Minister of Works. The problems in British Guiana are similar to those of Jamaica and Trinidad, especially that of technician training. The Technical Institute can provide all the teaching that is necessary for technicians, and avenues to the professional grades should not be overemphasized.

The projects visited were fascinating in their variety and interest—the bauxite mines and alumina plant, an irrigation scheme, local industries, the modern telecommunication system, etc.

Impressions of Barbados and the Bahamas

In Barbados, visits were paid to a power station; to the Technical Institute, where much good work has been done on the training of craftsmen; to a new housing estate; to a soil-conservation scheme; to a new hospital; to the new deep-water harbour with its interesting bulk-sugar store, already in use; to a sugar factory; and to the screw-lift dock, built in 1891.

An impression was gained of too many heads of works departments, of inadequate salaries, and of inadequate housing. These, of course, are closely related to the economy of the country and to the probability that more use could be made of technicians, whose training could well be undertaken by the Technical Institute if given more support by local industry.

In the Bahamas, visits were paid to local building works and town development; to a power station and evaporation plant, etc. A most interesting visit was to the water supply, drawn from shallow wells overlying the salt-water table in the coral beds. As the whole economy of the Islands depends on the tourist trade, a good potable water supply should take the highest priority.

A meeting was held with the Governor, and another with chairmen of the various commissions and corporations and others, at both of which the lack of properly trained tradesmen and technicians was emphasized. There is no technical college or trade school, and each department trains its own

employees, with much consequent duplication of effort. The Joint Group could give considerable assistance in organizing and advising on a suitable trade school, which local industry could support financially and by lending part-time teaching staff.

Summing up

On the engineering plane in the West Indies, projects of the highest professional and technical level were inspected and left little doubt as to the competence of the engineers concerned. The greatest need is obviously for technicians and tradesmen, and their training should be regarded as an end in itself. A few of the more competent may be transferred to professional courses elsewhere, but this should be regarded as secondary to the main object.

Each Joint or Professional Group Committee can provide valuable assistance to their Government in this matter and in some cases are already doing so. The pressure on professional staff would be greatly eased if such a policy were energetically pursued.

MECHANICAL ENGINEERS

BETWEEN the 25th February and the 5th April 1961, Prof. Owen A. Saunders and Mr. K. H. Platt, together with their ladies, toured the Far East on behalf of the three senior institutions to exchange information with members of Joint Groups and national engineering institutions. They visited Ceylon, Malaya, Singapore, Hong Kong, Japan, Pakistan and Aden.

Warm welcomes

The party received an extremely warm welcome from members of the three institutions oversea, as well as from members of national institutions. They were received by High Commissioners, members of Commonwealth Governments, and prominent men of the academic world, as well as being interviewed by local broadcasting and Press representatives.

In each country visited, Prof. Saunders and Mr. Platt had an opportunity of meeting numerous members of the institutions and other engineers on various social occasions and for discussions about institution matters.

In most countries they were also able to visit local engineering developments, such as hydroelectric schemes, power stations, industrial and harbour installations and research institutes, as well as technical colleges and universities.

Prof. Owen A. Saunders and his party admiring a Japanese garden near the tea-ceremony House of Happoen
Prof. Saunders is in the centre facing the camera

Visit to Japan

Of particular interest was the visit to Japan, where the party were received with great kindness by the President and senior members of the Japan Society of Mechanical Engineers. Japanese engineers repeatedly expressed the wish for closer contacts with their British colleagues, particularly for exchanges of papers and visiting lecturers, joint congresses, etc. There was a general desire in Japan to keep in touch with British engineering progress, and visits to atomic-energy establishments, universities and other places convinced the British party that the Japanese have much to offer in return.

The party found it difficult to summarize their impressions of so many and varied countries. Most of these are members of the Commonwealth and are therefore looking to this country for assistance and advice in the training of engineers and the development of technical and scientific enterprises.

One problem met with in most countries, other than Japan, was that of finding practical-training facilities for young engineers which would be acceptable to the three institutions. In many places, local industry is not sufficiently developed to provide these and it is not always possible to send young people oversea. Prof. Saunders felt that, bearing in mind particularly what H.R.H. the Duke of Edinburgh said during his Graham Clark Lecture, this was one problem that would have to be solved in the near future.

Local relations

The Joint Groups' relations with local engineering societies were also much under discussion, but the situation varied considerably with the countries concerned. Thus, in Malaya, recognition could well be extended to the national institution, whereas in other countries the best results could be obtained by the Joint Groups acting for some time to come as the focal points for professional engineers.

A parallel problem arises in the requests of many of the universities and technical colleges visited for recognition of their degrees as affording exemption from institution examinations. Here again, the problem varied with the standards of the colleges concerned and their training facilities. Prof. Saunders felt that there was a need to evolve a more uniform procedure between the three United Kingdom institutions.

The question of the engineer's status in society was also raised repeatedly, but the fact that the institutions were not directly concerned with this was generally accepted. It was suggested that the Commonwealth Engineering Conference might well take up the matter.

Worthwhile tour

On the whole, it was felt that the tour was very worth while and it strengthened links between engineers in Britain and oversea. There is a great deal in favour of one President going abroad to represent all three institutions on a tour such as this.

The articles in this regular monthly feature are based on current papers read at Institution meetings. They are written by the authors of the papers, who have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the articles bring out the main points and conclusions of the papers, their contents are not necessarily confined to the subject-matter of the original papers

Breakdown voltage of sphere-gaps in air

*A short article based on three papers and a monograph of the Measurement and Control Section: paper 3322 'Influence of humidity on the breakdown voltage of sphere-gaps and uniform-field gaps' by E. Kuffel, M.Sc., Ph.D., A.Inst.P.; paper 3371 'The influence of nearby earthed objects and of the polarity of the voltage on the direct-voltage breakdown of horizontal sphere-gaps' by E. Kuffel and A. S. Husbands, B.Sc.(Eng.), Member; paper 3372 'The direct-voltage calibration of air-gaps in a uniform field and between spheres up to 25 cm in diameter' by E. Kuffel; and monograph 329 'The effect of irradiation on the breakdown voltage of sphere-gaps in air under direct and alternating voltages' by E. Kuffel. The papers were published individually in February 1961 and will be republished in Part A of the Proceedings: monograph 329 was published individually in February 1959 and republished in Part C of the Proceedings (**106** C, p. 133). They were read at Savoy Place on the 21st February 1961 before a joint meeting of the Measurement and Control, Supply, and Utilization Sections (see p. 393). Dr. Kuffel was formerly, and Mr. Husbands is, in the Research Department, Associated Electrical Industries (Manchester) Ltd. Dr. Kuffel is now at the Manchester College of Science and Technology.*

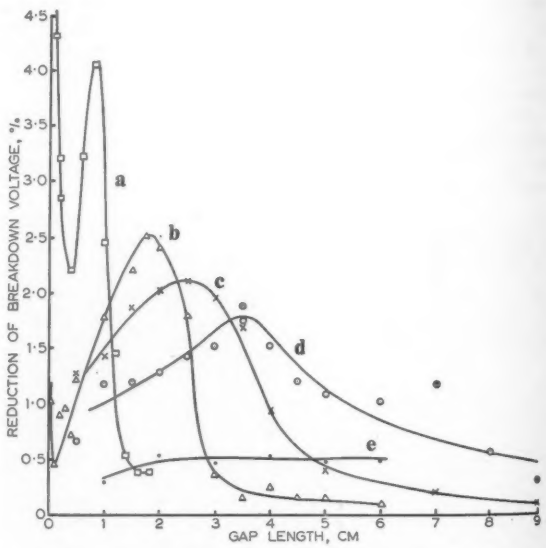
In suitable test conditions, the lowest voltage that will cause a spark breakdown of an air-gap between two metal spheres is sufficiently consistent each time to enable sphere-gaps to be used for the measurement of high voltage, provided that the gap-breakdown voltages are already known. A number of experimental calibrations have been correlated, and recently the recommended calibrations and test conditions have been revised by the International Electrotechnical Commission (Publication 52: 1960) and by the British Standards Institution (B.S. 358: 1960).

The papers describe investigations, which were made mainly with direct voltage, to evaluate the changes in the breakdown voltage resulting from certain changes in the test conditions.

Irradiation of the air-gap

The initiation of the breakdown process requires a definite minimum voltage between the two spheres, and it depends on the presence, at the critical time, of some free electrons in the effectively stressed volume of the air in the gap. In normal atmospheric conditions there may be a scarcity of free electrons in a short gap, and this condition causes an increase in the breakdown voltage if the voltage is applied for only a limited time. Some means for producing additional free electrons is required in order to obtain consistent results with small gaps. B.S. 358 recommends the irradiation of the gap from a radioactive source (e.g. 0·2–0·6 mg of radium) or from an ultraviolet lamp.

Sphere-gaps longer than 2–5 mm gave consistent breakdowns under direct voltage either with or without 0·5 mg of radium placed inside one of the spheres. The radium caused a decrease of up to 4% in the breakdown voltage (Fig. 1).



1 *Effect of gap irradiation on the direct breakdown voltage of sphere-gaps*

a 2 cm-diameter spheres
b 6·25 cm-diameter spheres
c 12·5 cm-diameter spheres
d 25 cm-diameter spheres
e parallel-plane electrodes

The irradiation of the gap caused an ion current that increased with the gap-length, and the resulting space charges tended to reduce the breakdown voltage.

There was a critical gap-length that gave a maximum irradiation effect (Fig. 1), and the critical gap increased with the sphere size. The distributions of voltage gradient E along the axes of the critical gaps were analysed (Table 1a). In each case the voltage gradients at the centres were approximately constant. The results indicate that the breakdown mechanism changed as the gaps were increased above the critical lengths.

Table 1. Variation of voltage gradients along the axes of the gaps which gave the maximum irradiation or humidity effect

a Irradiation effect

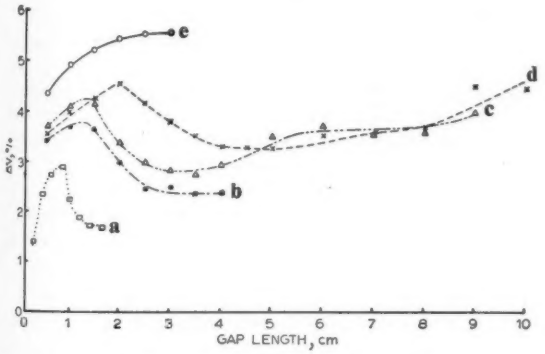
0·5mg radium; water-vapour pressure, 4mm Hg

sphere diameter	E_{max}	E_{min}
cm	kV/cm	kV/cm
2·0	41·0	27·2
6·25	34·4	26·2
12·5	31·8	26·1
25·0	30·0	26·1

b Humidity effect

No additional irradiation; water-vapour pressure, 12·5mm Hg; total pressure, 760mm Hg

sphere diameter	E_{max}	E_{min}
cm	kV/cm	kV/cm
2·0	36·4	28·6
6·25	34·9	28·7
12·5	33·6	28·3
25·0	30·6	28·6



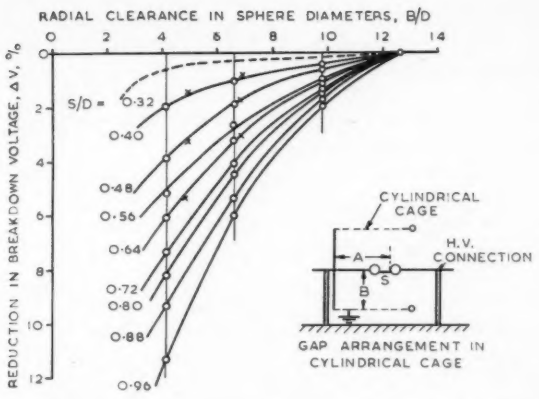
2 *Increase in direct breakdown voltage for different gap-lengths when humidity was changed from 0 to 17 mm Hg*

a 2cm-diameter spheres
b 6·25cm-diameter spheres
c 12·5cm-diameter spheres
d 25cm-diameter spheres
e plane electrodes

Air humidity

A change from dry to relatively humid air caused an increase of up to 4% in the direct breakdown voltage (Fig. 2). Molecules of water vapour, more so than air, tended to capture free electrons by a process of attachment, forming negative ions which made no contribution to the breakdown mechanism. Thus, the humidity effect counteracted that of irradiation in some respects. In common with the irradiation results, the humidity had its maximum effect at a critical gap-length for a given size of sphere (Fig. 2). The analysis of the voltage gradients along the axes of the critical gaps (Table 1b) showed that the minimum was approximately constant in each case.

Between the humidity limits of 4 and 17mm Hg of water-vapour pressure, the direct breakdown voltage increased approximately linearly with humidity for a given gap-length.



3 *Change in breakdown voltage of 6·25 and 12·5 cm-diameter sphere-gaps with radial clearance*

○ 6·25cm-diameter spheres
× 12·5cm-diameter spheres
Gap arrangement in cylindrical cage

Proximity of other objects

Earthed objects in the vicinity of a sphere-gap caused some distortion of the electric field between the spheres, and this tended to reduce the breakdown voltage. The influence of a cylindrical metal shield is shown in Fig. 3, where D is the sphere diameter, S is the gap-length, and B is the radial clearance. An earthed plane parallel to the gap axis at a distance A gave similar characteristics. When both a plane and a cylinder were present, and when one had the predominant influence, variations of the clearance to the other caused a negligible change in the breakdown voltage.

The earthed plane could be made a consistent feature in practice, so that its influence should be made to predominate by specifying a comparatively short clearance A. Then the radial clearance B could be specified at or above the value which had little or no additional effect on the voltage. A clearance $A = 4D$ is suggested for all sizes of sphere when the breakdown voltage is being calibrated.

Small influences

The polarity of the high-voltage sphere had an influence of 0·5% or less for gaps up to $S = 0{\cdot}75D$ between spheres

Papers read (continued)

up to 25cm in diameter. Positive polarity gave the higher breakdown voltage.

Copper or aluminium spheres gave similar results within 0·5%, with a tendency for the latter to give the lower values.

There was a small electrode-conditioning effect with successive spark breakdowns, and when the gap was in a small enclosure there was a small air-conditioning effect. The combined influence of these effects was 1% or less, and the breakdown voltage stabilized after the first few breakdowns.

Calibration of sphere-gaps

The breakdown of a sphere-gap can be repeated with a consistency better than the ±5% for direct or ±3% for alternating voltage quoted in the present specifications for the use of sphere-gaps. The improved consistency requires a closer control of the influences of irradiation, humidity and clearances from nearby objects, all of which factors may cause small random variations as they are specified at present. In particular, improved consistency and accuracy are desirable when calibrating the sphere-gaps.

Test conditions for this purpose should be specified separately from the corresponding conditions that may be recommended when a calibrated sphere-gap is used subsequently for the measurement of voltage. For the latter purpose, the test conditions could be similar to those used during the calibration, or the conditions might be relaxed by extending the permitted limits of variation if the best measurement accuracy were not required.

621.315.618.2 : 621.317.333.6 : 621.317.326 : 621.387 : 621.317.338.82

Behaviour of electric-railway-traction overhead equipment

A short article based on a Utilization Section paper (3530) 'A dynamic model for studying the behaviour of the overhead equipment used in electric railway traction' by D. S. Farr, Associate Member, H. C. Hall, M.Sc., and A. L. Williams, Ph.D., M.Sc., Member. The paper was published individually in February 1961 and will be republished in Part A of the Proceedings. It was read on the 16th March 1961 at Savoy Place before the Section (see p. 394). The authors are with British Insulated Callender's Cables Ltd.

It is not possible in practice to achieve the ideal of absolutely uniform current collection from a static overhead wire, traversed by a pantograph or pantographs mounted on a moving train. The overhead wire varies in rigidity, mainly because of its attachment to supporting structures but also because of its inertia and unavoidable changes in height above the track.

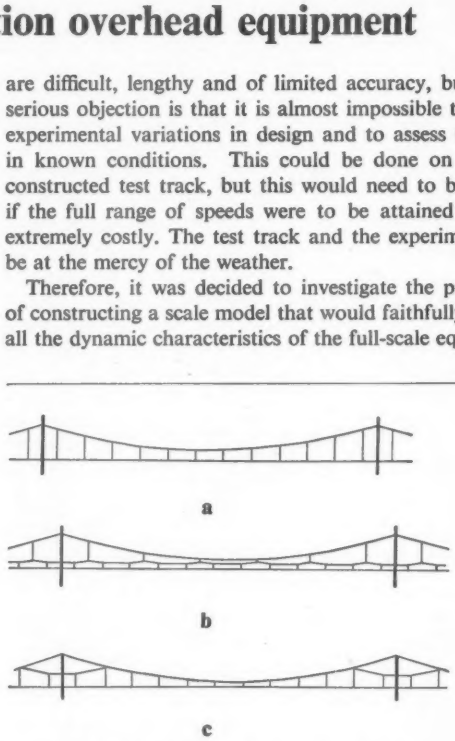
The pantograph, although designed to exert a constant upward pressure, has inertia that prevents an instantaneous reaction and aerodynamic resistance that makes its characteristics speed-dependent to some extent. Consequently, the contact pressure between the two components is continually changing, and, for satisfactory operation, it must be neither so low that electrical continuity is lost, with the attendant risk of the establishment of destructive power arcs, nor so high that excessive mechanical wear or damage is caused to the overhead equipment or pantograph.

The problem has been recognized for a long time, but it becomes more important as higher supply voltages, and hence lighter overhead wires, are used and as running speeds increase.

Railway-track observations

For information on the performance of his equipment, the designer has hitherto had to rely almost entirely on observations made on the actual railway track. Such observations are difficult, lengthy and of limited accuracy, but the most serious objection is that it is almost impossible to introduce experimental variations in design and to assess their effects in known conditions. This could be done on a specially constructed test track, but this would need to be very long if the full range of speeds were to be attained and hence extremely costly. The test track and the experiments would be at the mercy of the weather.

Therefore, it was decided to investigate the practicability of constructing a scale model that would faithfully reproduce all the dynamic characteristics of the full-scale equipment, at simulated speeds up to at least 100m.p.h. The three basic arrangements used in the British Railways 25kV a.c. system were selected for the research (Fig. 1).



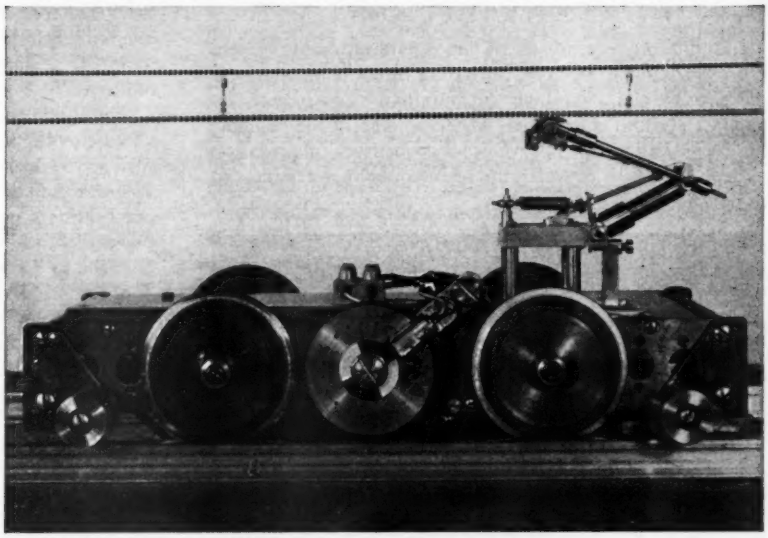
1 *Schematic elevations of three principal systems of overhead equipment*
a simple catenary
b compound catenary
c stitched catenary

Dimensional scaling

All the quantities that are involved (length, mass per unit length, extensibility, flexural rigidity, force, speed, acceleration, etc.) can be defined in terms of the three fundamental quantities, mass, length and time. Thus, if scaling factors are chosen for mass, length and time, the appropriate factors for all other quantities may be calculated by dimensional analysis. For example, the scale factor for speed (ft/s) is the scale factor for length divided by that for time.

Because both the full-scale equipment and its model must operate in the same gravitational field, the scale factor for acceleration (ft/s^2) cannot be other than unity. From this it follows that the scale factor for length must be the square of the scale factor for time, with the result that all quantities in the model may be defined in terms of only two scaling factors, length and mass.

For housing the models in a laboratory of reasonable size, a convenient scaling factor for length is about 40. Consideration of the forces in the system indicated a scaling factor for mass of about 1000.



2 *Trolley, showing modelled pantograph and overhead wires*

Experimental details

Because of an essential relation between density and elasticity, a construction was needed in which the elastic properties of a fine wire were associated with the density of a much larger one. This was achieved by fixing closely-spaced metal beads to a fine wire, the length of the beads and their spacing being so chosen that the scaled-pantograph contact strip rode along the beads without causing spurious vibrations.

To meet elasticity requirements, only two metals could be used for the wires—brass for the contact wire and tungsten for the catenaries—and, because of mass requirements, all dimensions were rigidly controlled, leaving only one practical solution. This gave scaling factors for length and mass of 32·5 and 1220 respectively. The same factors were used for modelling all the other parts of the overhead equipment and the pantograph.

The models were erected in a closed loop with an 80ft test section in each of the straight sides, so that ¼mile of track could be scaled. To carry the pantograph up to a speed of 18m.p.h. (representing about 100m.p.h.), an automatically controlled trolley was used, fitted with devices for measuring speed, acceleration and position (Fig. 2). Movements of the contact wire and catenaries at any position were measured by electrical or optical means.

Comparison of the behaviour of the model with that of the full-scale system showed that dynamic similarity had been achieved, and an extensive programme of investigation has now been started.

621.332.31 : 621.317.39

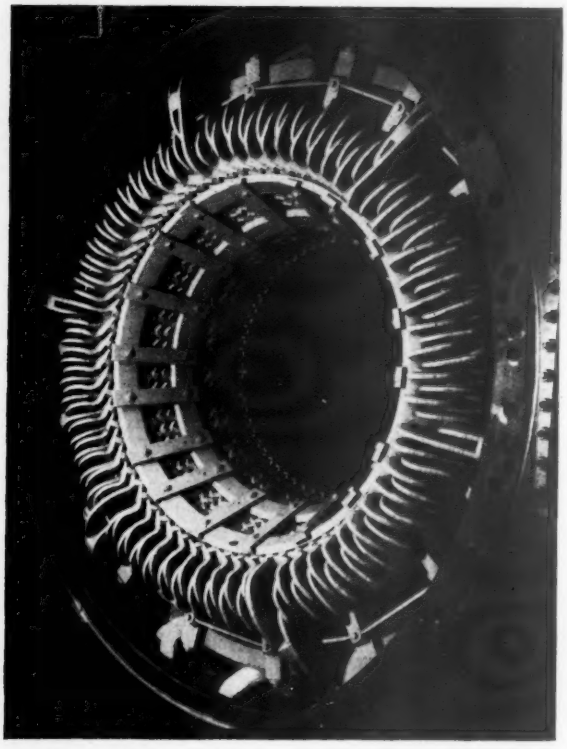
MAGNETIC FIELD OF TURBOGENERATOR END-WINDINGS

Two Supply Section papers were read before the Section on the 12th April 1961 at Savoy Place (see p. 396): paper 3489 'The calculation of the magnetic field of rotating machines. Part 2—The field of turbogenerator end-windings' by D. S. Ashworth, B.A., and P. Hammond, M.A., Member, and paper 3490 'The magnetic field of the end-windings of turbogenerators' by P. J. Lawrenson, M.Sc., Graduate.

This short article is based on both papers, which were published individually in March 1961 and will be republished in Part A of the Proceedings. *Mr. Ashworth is with the Turbine Generator Division, Associated Electrical Industries Ltd.; Mr. Hammond is in the Department of Engineering, University of Cambridge; and Mr. Lawrenson is with Associated Electrical Industries (Manchester) Ltd.*

During recent years there have been notable increases in the ratings of turbogenerators, permitting an increase in over-all generating efficiency and minimizing the capital cost per kilowatt. In particular, during the last ten years highest ratings have increased at least fivefold, despite the severe limitations on physical size set by the mechanical strength of the rotor and the transportable weight of the stator.

That this has been possible is almost entirely due to greatly improved cooling methods, including direct cooling of the windings by hydrogen under pressure and more recently by water. The more efficient use of the volume of the machine has been assisted by improvements in methods of excitation control, as a result of which the rotor/stator m.m.f. ratio can be reduced.



1 *Stator end and windings*

These increasing machine outputs have inevitably been associated with substantial increases in the current-density loading on both rotor and stator. For example, whereas ten years ago a stator current loading of 2500 ampere-conductors/in. of periphery was considered high, machines are now being built with loadings of 5000 ampere-conductors/in., implying conductor currents of perhaps 8000 A at about 3 in. spacing.

The effect of these increases in current loading has been to bring into prominence many problems that previously were of little significance. Of these new problems, several associated with the end regions of the machines, shown in Figs. 1 and 2, are of particular importance.

New problems

The first group of these problems is concerned with the stray losses, i.e. those power losses that are not fully understood or calculable. These stray losses are due to eddy and other circulating currents in the end regions, particularly in the stator-core end-plate and the stator windings. In a large modern machine they may amount to 1000 kW and therefore represent a significant quantity, which it is important to reduce.

In addition to lowering the machine efficiency, these stray losses can be the cause of overheating in localized regions, such as the roots of the stator teeth, and may eventually lead to severe damage to the whole machine. It is known that this overheating is particularly severe during operation at leading power factors, so that, if possible, special design changes should be made to eliminate the overheating.

A second group of problems is concerned with the large mechanical forces on the stator end-winding owing to the interaction of the currents in the windings. Particularly in short-circuit conditions, when instantaneous currents many times greater than normal are encountered, these forces can be considerable, reaching peak values of many tons per foot length of conductor. Forces of this magnitude can cause distortion and ultimate breakdown of the windings. To ensure that satisfactory bracing and support is provided, reliable knowledge of the magnitude and distribution of the forces must be available.

Nature and distribution of field

All the above effects are due to the field in the end region, and so, in investigating them, it is essential to study the nature and distribution of the field. This study is an extremely difficult one, for not only is the field generated by currents in a highly complex winding arrangement but also it is modified by complicated boundaries.

The stator winding is multiphase, and each coil has the

2 *Rotor end, showing the windings, before the fitting of the retaining ring*

shape of an involute laid on the surface of a cone; the rotor winding consists of concentric turns lying on the rotor shaft. The main boundaries are the core end-plate and the rotor body and shaft, but other structural parts, such as the machine casing, also influence the field. The influence of the boundaries is particularly difficult to examine, not only because of their complicated shape but also because different parts have different permeabilities and in some cases carry large eddy currents.

Probably the most obvious approach to the investigation of the field and its effects is by direct measurement. On production machines this involves the use of search coils and thermocouples and, on water-cooled machines, calorimetric methods. However, on production machines it is not possible to investigate the influence of varying design parameters, and, since scale models cannot be used, a full-sized experimental apparatus has been built. This is specially designed so that constructional features can be changed easily and thus evaluated.

Theoretical examination

The empirical information that these experiments yield, though of great value, is in itself insufficient. To be able to interpret the experimental results and especially to be able to predict confidently the performance of new designs, it is important to examine theoretically the nature of the end fields. From consideration of the complexity of the winding and boundary shapes, it is apparent that were it not for the availability of digital computers theoretical analysis would be impossible.

Two methods utilizing a digital computer have been developed by which the field of the windings, or of any three-dimensional current array, can be accurately calculated. In one, the whole winding is replaced by a combination of thin cylindrical current sheets, while in the other each coil is effectively replaced by its central filament.

No exact analytical or numerical treatment of the boundaries is possible; but, using the method of images and a fictitious current to represent the effect of the air-gap, it is possible to investigate the magnetic or eddy-current influences of the main parts of the boundaries. From results for the distribution of the fundamental and harmonic waves of the field, it is possible to see the influence of most parameters, including the straight projection of the winding, the cone angle of the winding, the coil pitch, the permeability of the core end-plate, and the operating power factor.

No calculation of the power losses or forces has been attempted (though for the latter this calculation is relatively simple), and the representation of boundary effects in particular regions leaves much to be desired. Nevertheless, the results do indicate many useful general features of the nature of the field to which these phenomena are due. It is hoped that they, and the methods by which they are derived, will form a starting-point from which a thorough understanding of end-field effects can be achieved, and that they will form immediately a useful framework for discussion.

621.313.322–81.013.2

REACTIVE-POWER SUPPLY

A short review based on a Supply Section paper (3528) 'Technical and economic aspects of the supply of reactive power in England and Wales' by W. Casson and H. J. Sheppard, B.Sc., Members. The paper was published individually in March 1961 and will be republished in Part A of the Proceedings. It was read before an Ordinary Meeting on the 6th April 1961 at Savoy Place (see p. 398). Mr. Casson is with the Central Electricity Generating Board, and Mr. Sheppard is with the Yorkshire Electricity Board.

In the Central Electricity Generating Board's power-supply system, the generators are connected and loaded in merit order in respect of cost of generation to meet the changing load during the day. This creates problems in meeting the demand of the system and load for reactive power.

At present, there is no automatic or semi-automatic method for meeting this demand, but its introduction will be necessary soon in view of the installation each year of compensating equipment in the transmission system such as synchronous compensators to provide more effective control. Such a method may require accurate planning to be carried out in advance to determine optimum settings of MVAr/MW output of the generators which would result in the maximum use being made of their capacity to generate reactive power.

These optimum settings would require the consumption of reactive power at bulk-supply points to be kept within a limited optimum range, which in turn would mean that Area Boards would have to persuade their industrial consumers not to generate the whole of their own requirements for reactive power.

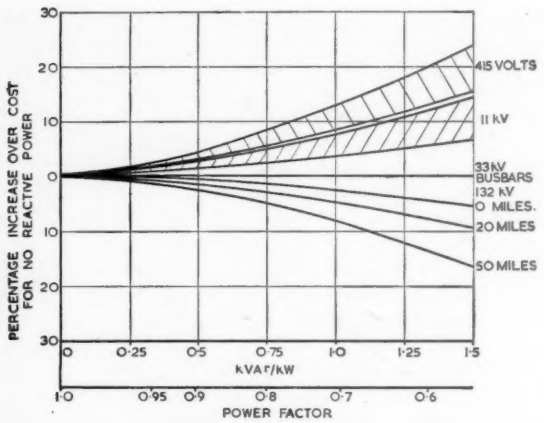
Reactive as well as active power

The increased costs of supplying reactive as well as active power in this country are chiefly those arising in the transmission and distribution system, the additional costs of generation being negligible for a power factor which is not usually below 0·9 at bulk-supply points. The additional costs arise from higher costs of heavier circuits, increased losses per kilowatt and a greater range of voltage regulation.

The costs have been estimated for a typical section of system comprising a double-circuit 132kV overhead line supplied from a generation busbar and terminating in transformers which give a 33kV bulk supply. The related distribution system provides m.v. supplies for the consumers, by means

of local transformation in one case and through typical 33kV and 11kV circuits in another case.

The increase in annual cost for supply at various points in the distribution system is shown in Fig. 1. The cost of



1 *Increase in annual cost for supply at various parts of system*

supply, after transmission at 132kV for 20 miles and subsequent transformation to 33kV, is about 3% more at 0·8 power factor than at unity power factor. Distribution at 33 and 11kV will raise this difference to nearly 7%, and further transformation and distribution at 415V will further increase it to about 9½%.

These figures indicate the approximate increase in demand charge, which should be obtained from consumers who take power from the supply system at 0·8 power factor at peak load, in order to cover fully the increased costs of transmission and distribution. It is, however, most desirable to avoid increasing the power factor at bulk-supply points beyond the optimum, which is likely to be about 0·93 for the conditions expected when the total load reaches 30GW.

Tariff adjustments

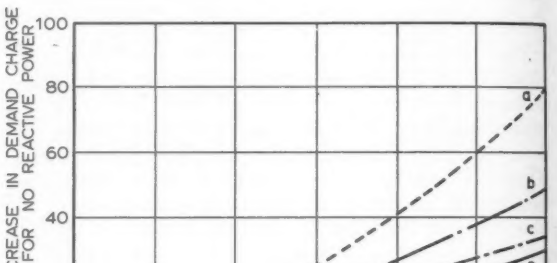
The effects of applying the three principal forms of tariff used in Britain for persuading consumers with inductive loads to provide their own sources of reactive power, or reimbursing the Area Boards for the additional cost of supply, are shown in Fig. 2. It will be seen that, if the kVA demand tariff (curve **a**) and the (kW + kVAr) demand tariff (curve **b**) are correct in recovering costs when there is no reactive-power demand, the additional costs for transmitting and distributing reactive power (curve **e**) will be over-recovered.

This effect is inherent in the kVA demand tariff, but the demand charge having the form £[*a*kW + *b*(kVAr − 0·4kW)] is fully adjustable since *a* and *b* can be varied independently when necessary. In the third form of tariff, the 'average power factor' may be used to adjust the kW demand charge of a tariff in various ways, with results such as those shown in curves **c** and **d**.

Capacitor installation

The provision of a tariff inducement for a consumer to generate reactive power gives him full scope to select the most advantageous method. For example, in considering an installation of capacitors, the consumer is likely to regard it in the same way as he looks at other installations of plant and to seek a return which will enable his capital outlay to be amortized within a short period, such as five years.

Comparing, for various load power factors, the annual cost of a capacitor installation added to the increased kVA demand charges, it is found that significant savings accrue to the consumer who corrects from 0·8 power factor to the



2 *Effect of tariff adjustment for power factor on demand charge*

a kVA demand
b kW + 0·45 (kVAr above 0·4 × kW)
c kW + 1% for each 0·01 below 0·9 power factor
d kW + 2% for each 0·05 below 0·85 power factor
e increase in annual cost for typical transmission and distribution system

optimum of about 0·98 but that there is no incentive for him to install capacitors if the load power factor is as high as 0·90. Similar comparisons can be made for other tariffs and lead to the conclusion that most of the existing methods of tariff adjustment provide a strong inducement to consumers to improve the power factor of their demands to between 0·89 and 0·98.

621.311.1.026.5

CORRECTION

In Mr. R. Hawley's article 'Vacuum as an insulator' (April 1961 *Journal*, p. 233), a mistake occurred in Fig. 1. The average breakdown stress(vertical axis) should be in V/cm × 10^4 and not in V/cm.

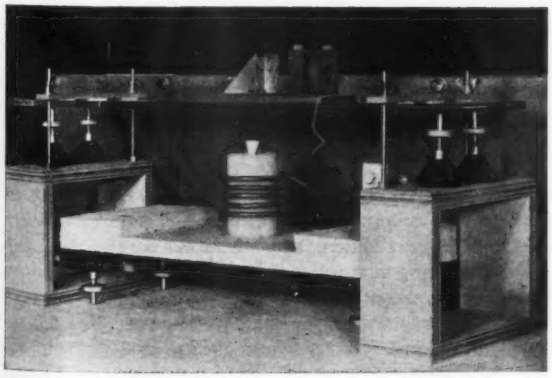
In this monthly section are articles based on, or summaries of, papers published in the *Proceedings* of The Institution that have not been read at Institution meetings. The articles are on topics of some general interest and are written by the authors of the papers. The authors have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics covered. The contents of the articles develop the main points and conclusions of the papers, although their subject-matter is not necessarily confined to that of the original papers. The summaries are included primarily for reference. Reprints, price 2s., become available about two months after publication

Units and standards of light

A short article based on a Measurement and Control Section paper (3573) of the 'integrating' type 'Units and standards of light maintained at the National Physical Laboratory, 1915–60' by J. W. T. Walsh, O.B.E., D.Sc., Member, the late W. Barnett, R. G. Berry, B.Sc., Associate Member, and J. S. Preston, M.A., F.Inst.P., Member. The paper is published this month in Part A of the Proceedings. Messrs. Berry and Preston are at the National Physical Laboratory, whence Dr. Walsh retired in October 1951.

THE years following 1915 saw the obsolescence of flame standards, e.g. the Vernon Harcourt ten-candle pentane lamp, as primary standards of light, and of carbon-filament electric lamps as secondary standards. In 1921, Great Britain subscribed to an international agreement which had the effect that this country discarded flame standards altogether and maintained the unit of luminous intensity—then the international candle—in terms of carefully conserved filament-lamp secondary standards, pending development of the present primary standard.

Work on this started in 1929 and came to fruition in 1937–39 with an international intercomparison of results, in terms of the international candle, obtained in seven countries including the United Kingdom. The outbreak of war delayed the full international adoption of this standard until 1948, so that, at the National Physical Laboratory and several other national laboratories, continuity of the scale of light measurement was preserved solely by means of secondary-standard electric lamps from 1921 to 1948. Meanwhile, the N.P.L. played a very active part in experiments with the new standard and in preparations for its adoption.



1 *Primary standard of light*

The crucible, containing platinum and black-body cavity, is within the heating coil of an induction furnace; the prism and lens form an image of the cavity on a photometer (not shown)

Primary standard of light

The form of primary standard of light (Fig. 1) now in force internationally consists of a black-body (or cavity) radiator held at the temperature of freezing platinum (2042° K). The corresponding unit of luminous intensity is the 'candela' (cd). By definition, the brightness or luminance of the radiator is 60 cd/cm^2. The figure 60 was chosen to ensure continuity, so that, within limits of experimental error at the various relevant dates, an intensity of 1 cd is the same as the older international candle, which in turn was approximately equal to the intensity of the earliest standard sperm candle.

The platinum primary standard was set up at the N.P.L. again in 1954, and a further extensive series of readings was taken and used both for internal checking and for comparison with the contemporaneous results of other national laboratories.

It is a disadvantage that, although the physical basis of the primary standard is sound and universal, the operating temperature, like that of the earlier flame standards, is much below that of the common gas-filled lamp. In fact, the increasing use of the gas-filled lamp and of associated fittings, from about 1920 onwards, posed the remaining two major problems that have occupied N.P.L. work on photometric standards in the period under review. First, a scientific basis and practical methods for comparing lights of different spectral qualities had to be established; and, secondly, methods had to be evolved for measuring not only the directional intensity of a lamp but also the total light emitted in all directions.

Secondary standards

In the first problem, the crucial step was international agreement, in 1924, on a standard table of figures representing the spectral response of the average normal eye. The second step was the establishment of a standard blue-glass filter, whose light transmission could be computed from spectrophotometric measurements and which could be placed in front of a lamp working at about 2000° K to make its light match that of a lamp at about 2400° K, so that comparison

Papers published (continued)

of their intensities in a visual photometer was not impeded by a marked difference in colour.

Thus, by comparison with filament-lamp intensity standards working at about 2000° K and calibrated with reference to a low-temperature primary standard, it was possible to institute another set of intensity standards consisting of tungsten-filament vacuum lamps working at about 2400° K.

Here the second problem fitted in, because the only way of measuring the output of a lamp in directions other than the horizontal was to tilt the lamp and not the photometer bench. It was preferable also to spin the lamp in order to economize effort in getting average readings. This meant that vacuum lamps working at about 2400° K had to be used, gas-filled lamps not being stable in these circumstances. Thus, secondary standards of total light (flux) working at 2400° K were set up by reference to the intensity standards at 2400° K. Finally, gas-filled flux standards at about 2800° K were set up by comparison with the vacuum standards working at 2400° K in an integrating sphere photometer, again with the aid of the calibrated blue glass.

Although since 1945 photoelectric methods of photometry have completely superseded visual-cum-blue-glass methods, the N.P.L. tungsten-filament secondary standards still include two groups of intensity standards embodying the candela, and working respectively at about 2000° and 2400° K, and two groups of flux standards embodying the lumen, at about 2400° and 2800° K. The lumen may be defined as follows: if a uniform point source of intensity 1 cd in all directions is situated at the centre of an imaginary sphere of unit radius, the lumen is the amount of light flux falling on unit area of the sphere. A source of mean spherical candle-power 1 cd emits 4π lm.

This scheme of secondary standards remains convenient while a primary standard working at 2042° K remains in force and until a modern method of measuring the total output of a lamp by scanning around it with a photoelectric cell has been developed.

International field

The N.P.L. has, in addition, played a very full part in the international field from the earliest times, having itself undertaken some of the earliest international comparisons of photometric standard lamps. It has taken part in fuller comparisons in 1948, 1952 and 1956 under the aegis of the Bureau International des Poids et Mesures (at Sèvres, near Paris), Great Britain being one of the treaty countries maintaining the B.I.P.M.

Table 1 shows how the units maintained in different countries differ currently from the mean units at present maintained at the B.I.P.M., as revealed by the last comparison in 1956–58. Zero entries indicate countries that then adjusted their units to equality with the B.I.P.M. mean units. For reasons that are too detailed to state here, the remaining countries deferred this adjustment.

Table 1. Differences of individual units* from the B.I.P.M. mean, March 1958

Country	Candela		Lumen	
	2042° K	2353° K	2353° K	2788° K
	percentage		percentage	
Germany	0	0	0	0
United States	+0·1	−0·1	0·0	0·0
Canada	−0·5	−0·3	0·0	+0·9
France	0	0	0	0
Japan	0	0	0	0
Soviet Union	−0·5	+0·2	−0·3	−0·4
United Kingdom	−0·1	−0·1	+0·2	+0·7

* It should be remembered that the photometric value assigned to a lamp is inversely proportional to the magnitude of the unit employed. A lamp working at 2042° K, and having an intensity of 100 cd as measured in Canada, would have an intensity of 99·5 cd as measured in Japan, according to the two relevant entries in the first column of the table

Present studies

Since 1958, the chief photometric project under study at the N.P.L. has been the possibility of establishing the unit of luminous intensity by an independent technique making use of absolute measurement of radiant power. The technique is well suited to the direct calibration of secondary standard lamps working at high temperatures and so, if successful, might eventually displace the use of the present primary standard on practical as well as logical grounds. Preliminary attention is being given to possible economic methods of deriving standards of flux that do not demand the use of low-temperature lamps.

621.317.39 : 389.16 : 535.24

Floor-thermal-storage heating of buildings

A short article based on a Utilization Section paper (3532) 'Measured and electrical-model characteristics of buildings heated by floor thermal storage' by E. D. Taylor, M.Sc., A.Inst.P., and B. Berger, B.Sc.(Eng.), Associate Members, and G. Blaylock, B.Sc. The paper is published this month in Part A of the Proceedings. The authors are with C. A. Parsons and Co. Ltd.

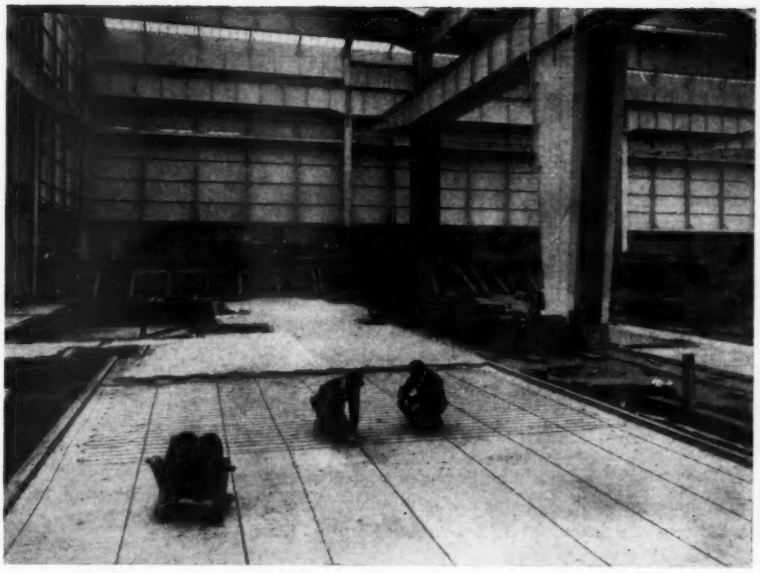
HEATING a building by the use of cables buried in its floors is now a well established principle; in Fig. 1 such a cable is shown being installed in the corner of a large single-storey factory. As a heating system it can be designed to produce conditions of comfort; it is competitive economically when run as an off-peak system, and this aspect is valuable to the power-generating authorities because of the improvement in load factor.

Heating a building during the day by power used during the night is rather different from the usual scheme: to an electrical engineer this resembles the application of a pulse to an electric circuit in which certain conditions are required effectively out of time-phase with the duration of the pulse. In the building, the pulse is usually in the form of a constant

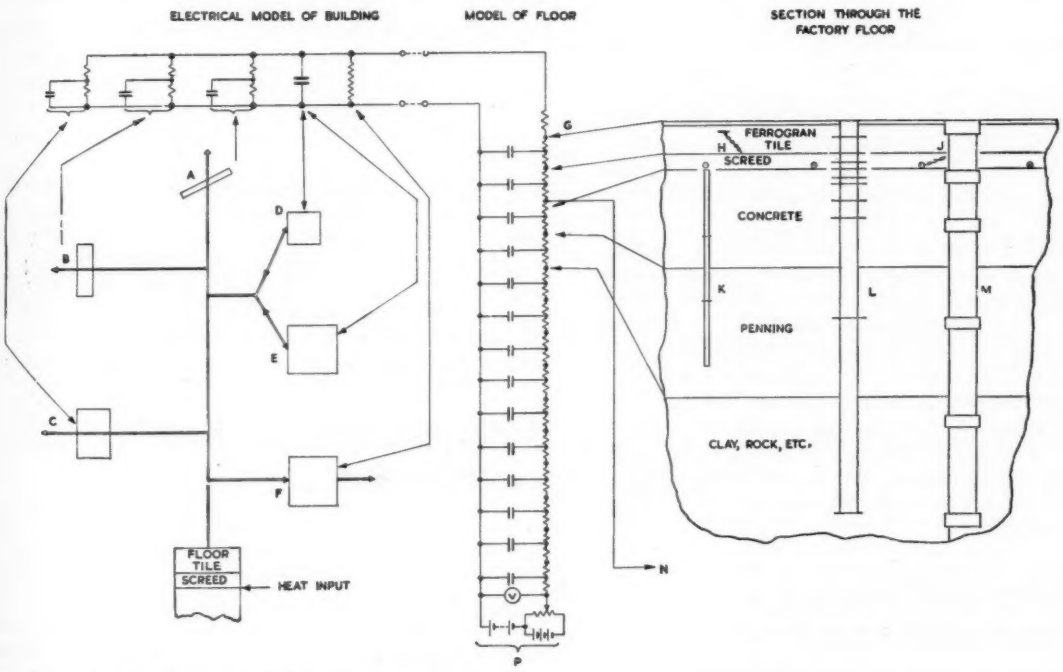
power input for a variable time, and the conditions are certain specified maximum and minimum temperatures over a given period.

It is possible to design off-peak-heated buildings by the usual methods in which the average heat loss of the building is computed from the U-factors of the structure. (The U-factors are the commonly used summaries of structure properties in the form of air–air thermal conductances of the various forms of construction used.) The total heat loss is then equated to the required power input. Certain other empirical data, the intelligent use of thermostats, and common sense will generally ensure a satisfactory installation.

These methods will not give the variation of temperature to be expected, and there are many questions about the behaviour of such buildings that cannot be answered accurately or simply by them. For example, in a single-storey building, how much power is lost to the ground? In a



1 *Floor-heating cable being installed in a large single-storey factory*



2 *Electrical representation of large single-storey factory*

Effect (A—F only) on average square foot of floor of:

- A Glass roof
- B Celotex and aluminium wall
- C Brickwork
- D Structural steelwork
- E Inside air
- F Loss in ventilation air

- G Floor-surface heat-transfer coefficient resistor
- H Heat-flow measuring device
- J Thermocouple to heater
- K 1ft temperature probe
- L 2ft temperature probe
- M 7ft temperature probe
- N Current representing heat input, from constant-current unit
- P Battery representing difference between outside-air and deep-subsoil temperatures

multistorey building, what will be the required heat inputs to the various floors? What will be the temperature variations with certain additional intermittent heat gains, and so on?

A thermal analogue

When large installations are involved, these questions can be of great importance from the points of view both of comfort and of the economics of the installation. Their solution provides an ideal opportunity for using a thermal analogue. That is to say, since the differential equations of heat flow and electric-current flow have the same form, heat flow in a building can be represented by the behaviour of an analogous electric circuit. In the circuit can be incorporated the heat-transfer relations of the floor, local heat gains within the building, ventilation and, of course, changes in the outside ambient conditions.

The authors describe in the paper how they set up the analogue of a very large single-storey factory entirely heated by an off-peak-heated floor, the circuit of the analogue being that shown in Fig. 2. At the same time, they were able to take detailed measurements on the factory. This they did by inserting in the ground many deep temperature probes, as well as heat-transfer discs near the surface. It was demonstrated that the simulator clearly predicted the behaviour of this 3 MW installation.

The great value of a simulator here is that one can very rapidly alter the circuit parameters to find out how effective are such things as edge insulation, double-glazing or sub-floor insulation. It is possible to see clearly how such an installation improves in its efficiency over a period of a few weeks—a point that would be impossible to measure on an actual building because sufficiently constant conditions are unobtainable.

In a multistorey block heated by off-peak thermal storage, rooms are heated mainly from the floor but also partly from the ceiling; the relative amounts depend very much on the construction. Here again, an analogue can tell fairly accurately how the heat will be distributed between the various floors of the building and what will be the temperature swings. This information can lead to the most economical design.

The analogue is a tool provided by the electrical engineer. As a heating engineer concerned with transient-heating methods, he will on occasion find it of great advantage to make use of the tools he has himself provided.

621.365.41 : 621.317.39

Inductance coefficients of a salient-pole alternator

A summary of a Supply Section paper (3587) 'The inductance coefficients of a salient-pole alternator in relation to the two-axis theory' by Prof. G. W. Carter, M.A., Member, W. I. Leach, M.Sc., Graduate, and J. Sudworth, M.Sc., Student. The paper is published this month in Part A of the Proceedings. Prof. Carter is Professor of Electrical Engineering, University of Leeds. Mr. Leach and Mr. Sudworth were formerly at the University of Leeds and are now with the Brush Electrical Engineering Co. Ltd.

The simplicity of the machine equations in their two-axis form depends on a certain relation between the inductance coefficients being satisfied. The condition is likely to be fulfilled in a machine having a uniform air-gap, but in a salient-pole machine its fulfilment is open to doubt. The authors present a theoretical and experimental study of the question; the experimental aspect has required the development of new methods of measuring the machine constants. 621.313.322.013.2

Loss distribution in electrical machines

A summary of a Measurement and Control Section paper (3548) 'A method of measuring loss distribution in electrical machines' by A. J. Gilbert, B.A., Associate Member. The paper is published this month in Part A of the Proceedings. The author is in the Heavy Plant Division, Associated Electrical Industries Ltd.

The author considers the need for new measurement techniques for the investigation and evaluation of machine behaviour. The disadvantages of former methods of core-loss measurement are dealt with, and an improved thermal method, based on the principle that the initial rate of rise in temperature at any point is proportional to the loss generated at that point, is explained. It is shown theoretically that, to achieve sufficient accuracy, measurements must be made over a short time.

This requirement is met by the use of a chopper-type d.c. amplifier and recorder to measure the e.m.f.s generated in thermocouples. The measuring equipment is described, and the effects of stray a.c. pick-up are discussed. Examples of applications are given that show that not only can the core-loss distribution be measured but also the effects of changes in geometry or materials can be studied by tests on a single production machine. 621.313.1.017.3 : 621.317.43

A self-optimizing non-linear control system

A summary of a Measurement and Control Section paper (3523) with the above title by J. L. Douce, Ph.D., M.Sc., and R. E. King, Ph.D., M.Sc., Graduates. The paper will be published in Part B of the Proceedings. Dr. Douce is, and Dr. King was formerly, in the Electrical Engineering Department, Queen's University of Belfast. Dr. King is now at the National Physical Laboratory.

A general technique of self-adaptation is presented that adjusts one parameter of a control system to obtain the best response as determined by some built-in optimizing criterion. The method has been applied to a position-control servomechanism in which the damping factor is automatically

adjusted to give minimum mean squared error. The response of the control system is considered for repetitive step functions and for sinusoidal and random signal inputs.

The addition of the self-adjusting feature requires little knowledge of the controlled-process dynamics or applied-signal characteristics. The optimization mechanism compensates for variations in system parameters, non-linear effects and changes in the applied signal.

It is shown that the introduction of a self-optimizing element gives a substantial improvement in system performance. Experimental results using an analogue computer are in good agreement with theoretical predictions. 621-526

Non-linearity in feedback control

A summary of a Measurement and Control Section paper (3568) 'Describing-function expressions for sine-type functional non-linearity in feedback control systems' by B. P. Bhattacharyya, B.E., C.E., M.E. The paper will be published in Part B of the Proceedings. The author is in the Electrical Engineering Department, Bengal Engineering College, Howrah, India.

THE author derives describing-function expressions for a sine-type functional non-linearity. In feedback control systems, non-linearities of this type are encountered where synchros are used as error-sensing devices and the controlled variable undergoes large-angle variations.

The characteristic curve of the non-linearity is approximated by straight-line segments over the entire angular range from $-\pi$ to $+\pi$ radians; the slopes and break-points are obtained by minimizing the mean square error between the exact and approximate characteristics.

The describing-function expressions are useful for studying sustained oscillatory states of feedback systems comprising such elements. An example is given to illustrate this point. 621-523

Electrodynamic multiplier

A summary of Measurement and Control Section paper (3594) 'A simple electrodynamic multiplier using torque balance' by J. G. Henderson, B.Sc., Associate Member. The paper will be published in Part B of the Proceedings. The author is in the Department of Electrical Engineering, University of Birmingham.

AN electrodynamical multiplying system is described that uses simple limited-range torque motors in a torque-balance feedback system. Certain inherent errors exist, and the conditions for keeping these within tolerable limits are indicated. 621.313.323: 621-52

THE JOURNAL DIGEST | MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monograph as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Analytical determination of the characteristics of enclosed and oil-immersed fuses

Monograph 449S

C. ADAMSON, M.SC.(ENG.), *and* M. VISESHAKUL, M.SC.TECH., PH.D.

PREVIOUSLY, the authors have dealt with semi-enclosed fuses manufactured from uniform thin strip or with single or double discontinuities in their cross-sections. An analytical solution for the time/current characteristic of such fuses was shown to exist. The solution was in very close correlation with experimental derivations of the same characteristics.

This work has now been extended in two ways. First, the analytical derivation of fuse characteristic has been extended to fuses with n discontinuities in their cross-sections, where $n > 2$; this work has been carried out to investigate the full range of alternative characteristics available from such fuses. Secondly, the solution obtained for a semi-enclosed fuse has been extended to fuses of similar metallic construction but immersed in oil or enclosed in a silica-type filler. This is the most important part of the work.

A method and form of solution having been established, a substantial amount of computation is necessary in any one case; in order to facilitate computation, a simple form of transient analogue computer, which is described, has been used. For fuses immersed in oil or enclosed in silica-type filler, the main problems have been to establish the parameters of heat transfer before finding a form of solution of the relevant equations.

The appendixes contain representative tables of results in the form in which they were obtained from the analogue computer and an analysis showing the feasibility of establishing a single series of tables of analogue-computer results for fuses with multiple discontinuities in their cross-section.

The launching of surface waves by an end-fire array of slots

Monograph 450E

PROF. A. L. CULLEN, O.B.E., PH.D., B.SC.(ENG.), *and* J. A. STANIFORTH, PH.D.

AN end-fire array of slots suitable for launching a surface wave on a dielectric-coated metal sheet is described and analysed. The analysis is based on the representation of the slots as magnetic dipoles in the plane of the sheet, their axes being perpendicular to the line of the array.

In a practical embodiment of the scheme, the elements take the form of slots fed by quarter-wavelength branch guides, in turn series-fed from a waveguide partially filled with dielectric mounted beneath the metal sheet. Experimental results are given which support the theoretical conclusion that a high launching efficiency is possible. For a 12-slot array launching a surface wave on a metal sheet coated with dielectric of relative permittivity 2·56 and of thickness 0·125in., a theoretical launching efficiency of 95% is obtained at a frequency of 1·38Gc/s.

Monographs (continued)

Backward waves in waveguides containing dielectric

Monograph 451E

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D.

A method is described for determining the conditions that ensure backward-wave propagation in dielectric-loaded inhomogeneous waveguide structures. It is established that backward-wave propagation can be ensured for the hybrid H_{11}-mode in a circular waveguide containing an axial dielectric rod whose relative permittivity exceeds about 9·4. The possibility of other inhomogeneous-waveguide modes exhibiting backward-wave properties is examined.

The relation between discrete periodic inputs, the transfer function and the transient response of a system

Monograph 452M

T. GLUCHAROFF, M.E.

SAMPLED-DATA systems are characterized by the presence of discrete signals at some point in the system, but the over-all output is usually a continuous function of time. The pulse sequence of discrete periodic signals, which result in a finite-settling-time response when applied to the input of a system, can be determined directly from the system transient response. Such a sequence can be used to design a discrete controller to compensate the system when its transfer function is not known.

Further, the transfer function of a system can be found, once an input pulse sequence has been determined, with an accuracy limited only by that of the given transient response.

A theoretical and analogue approach to stray eddy-current loss in laminated magnetic cores

Monograph 453U

D. A. JONES, B.SC., PH.D., *and* W. S. LEUNG, B.SC.(ENG.), PH.D.

A method of obtaining the interlaminar eddy-current loss in laminated magnetic cores is devised by using a resistance-network analogy. It is assumed that in a laminated-core section the flux distribution is uniform, that there is a uniform resistivity in the direction across the laminations and that the *IR* drops in the direction along the planes of the laminations are negligible compared with those in the perpendicular direction. The stray eddy-current loss is derived as a function of the resistivity ratio between the two directions. The network analogy leads to the subsequent estimation of the effect on core loss of any short-circuit paths in the section.

An experimental technique was developed to investigate the eddy-current distribution in any conductive network through which a uniform alternating magnetic flux passes. The eddy-current distribution for an isotropic section was first obtained. An analogy to the laminated-core section from the point of view of conductivity was obtained using a differential wire network whose resistivity in one direction was about 10^4 times that in the perpendicular direction. The eddy-current distribution in such a network in an alternating magnetic field was found to confirm the theoretical calculations for core sections with and without interlaminar short-circuits.

A hunting analysis of a permanent-magnet alternator and a synchronous motor

Monograph 454S

M. H. WALSHAW, B.SC.(ENG.), *and* J. W. LYNN, M.SC., PH.D.

LITTLE has hitherto been written about the transient analysis of interconnected salient-pole synchronous machines of comparable size, where infinite busbars cannot be assumed to exist.

The authors describe theoretical and practical work carried out on a simple power system of this type, in which a 60 kW permanent-magnet alternator supplies power to a synchronous motor. For analytical purposes, the permanent-magnet alternator is shown to be equivalent to a conventional alternator with a constant field voltage. The measurement of the parameters of the machines is described, and the steady-state performance of the interconnected system is predicted by Kron's method of analysis.

The hunting equations of the system are examined, and a frequency-response method involving Nyquist's stability criterion is used to predetermine the effects of armature resistance on the hunting stability of the system in various conditions of load and saturation. A digital computer is used to perform the calculations, and the predicted results are found to agree well with those obtained experimentally from the actual system.

THE JOURNAL DIGEST | IN THE PROCEEDINGS

The date in italics is that of the Journal review, special article or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (JUNE 1961)

J. W. T. WALSH, O.B.E., M.A., D.SC., W. BARNETT, R. G. BERRY, B.SC., *and* J. S. PRESTON, M.A. PAPER 3573M **Units and standards of light maintained at the National Physical Laboratory, 1915–60** *June 1961*

L. GOSLAND, B.SC., *and* R. G. PARR, B.SC.(ENG.). PAPER 3314S, AUGUST 1960 **A basis for short-circuit ratings for paper-insulated cables up to 11kV** *February 1961*

G. S. BUCKINGHAM, B.SC.(ENG.). PAPER 3284S, JULY 1960 **Short-circuit ratings for mains cables** *February 1961*

Communicated discussion on **The application of the method of images to machine end-winding fields**

O. I. BUTLER, D.SC., *and* V. AHMAD, PH.D. PAPER 3226U, MARCH 1960 **A new form of crane-hoist control using a 3 : 1 pole-changing induction motor** *April 1961*

R. A. WEST, B.SC.(ENG.). **New crane-hoist control** (communication)

E. D. TAYLOR, M.SC., B. BERGER, B.SC.(ENG.), *and* G. BLAYLOCK, B.SC. PAPER 3532U **Measured and electrical-model characteristics of buildings heated by floor thermal storage** *June 1961*

Communicated discussion on **An experimental study of surges and oscillations in windings of core-type transformers**

A. J. GILBERT, B.A. PAPER 3548M **A method of measuring loss distribution in electrical machines** *June 1961*

E. R. RADWAY. PAPER 3365U, DECEMBER 1960 **Some notes on the electrical requirements of general-cargo docks** *May 1961*

Communicated discussion on **Engineering education at the technical universities in Western Germany**

PROF. G. W. CARTER, M.A., W. I. LEACH, M.SC., *and* J. SUDWORTH. PAPER 3587S **The inductance coefficients of a salient-pole alternator in relation to the two-axis theory** *June 1961*

Communicated discussion on **The two-phase induction motor used as a servomotor**

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MAY 1961)

See the Journal for May 1961, p. 311

PART C. MONOGRAPHS (MARCH 1961)

See the Journal for March 1961, p. 179

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

NORMAN AXFORD

Norman Axford, B.SC.(ENG.), who died on the 5th February 1961 was born on the 3rd August 1897. He was educated at Christ's College, Finchley, at Regent Street Polytechnic, and at University College London, where he obtained his degree. He received his early training with the British Thomson-Houston Co., joining the Northmet Power Co. in 1923. He was assistant engineer at the Edmonton and later the Southgate districts. In 1926 he was promoted senior assistant engineer at Southgate. In 1933 he became resident engineer of Wood Green district and in 1937 became superintendent of Harrow district. He left Harrow in 1950 to become manager of Plymouth district of the South Western Electricity Board, but owing to ill-health retired at the end of 1958.

An interesting character, musical and accomplished in amateur dramatics, he was responsible on two occasions for the dialogue and lyrics in two satirical revues produced by the Northmet Operatic Society.

Keen on public relations, he was a former president of Harrow Rotary Club and also of Greater Harrow Chamber of Commerce. He was cryptic in his reaction when holding a different point of view, but charming in his ways; he was quite an enthusiast in certain spheres, particularly model railways. He was a member of the Model Railway Club, Harrow, and constructed a scale model of the railway yard at Newton Abbot.

He joined The Institution as a Student in 1921 and was elected a Graduate in 1926, an Associate Member in 1929 and a Member in 1948. He served as honorary assistant secretary of the South-Western Sub-Centre from 1952 to 1955 and as vice-chairman from 1955 to 1959. W. N. C. C.

STEPHEN HAYTER CHASE

Stephen Hayter Chase who died on the 12th February 1961 was born on the 28th September 1888. He was educated at Tottenham Grammar School and received his electrical engineering education at Finsbury Technical College. On leaving college in 1907 he branched off from electrical work for a period when he joined the agricultural machinery and tractor firm of Clayton and Shuttleworth, Lincoln. In 1911 he went oversea to represent the firm in Buenos Aires and remained there until the outbreak of the First World War, when he returned to Britain. He joined the Royal Army Service Corps and served in France, being demobilized with the rank of captain in 1919. He returned to Clayton and Shuttleworth for a short period as assistant to the general works manager.

In 1923 he joined the Chloride Electrical Storage Co. as a sales engineer in the London area, soon becoming sales manager for S.E. England in the sale of stationary and traction batteries. In 1955, a year before he retired, he was sales manager for Great Britain of the stationary-battery department of Chloride Batteries Ltd.

He had a wide circle of friends in the electricity supply industry, among the consulting and telephone engineers and in electrical contracting. His imperturbable and cheerful manner endeared him to all.

He was a keen freemason. He was a member of the Batti-Wallahs Society and, among other spare-time activities, took an interest in sailing. He is survived by his widow, two sons and a daughter.

He joined The Institution as a Graduate in 1924 and was elected an Associate Member in 1928 and a Member in 1952. His paper 'Emergency lighting systems and their applications, with particular reference to battery equipments' was published in the *Journal* in 1944. E. R. S.

WILLIAM WILSON COOK

William Wilson Cook who died on the 16th December 1960 was born at Birkenhead on the 2nd February 1867 and was educated at Wallasey Grammar School and at Finsbury Technical College. He was one of the early workers in the telephone field, having joined the United Telephone Co. as an electrician in 1884, and will be remembered as a consultant following the transfer to the Post Office of the National Telephone Co.'s system at the end of 1911.

In 1899 he went over to the Western Electric Co. as manager of their newly-acquired cable factory at North Woolwich, and it is in retrospect perhaps the best tribute to his qualities as an engineer that four years later Sir (then Mr.) Frank Gill, who had been called to London to be engineer-in-chief, persuaded Cook to return to the National as his assistant at a critical time in its history.

The arbitration in 1912 on the purchase price to be paid by the Post Office for the company's plant brought into full view much confusion of thought then prevailing on engineering economics, and led Gill and Cook to write a paper on 'Principles involved in computing the depreciation of plant', which they read before The Institution in 1917. At that time they had already been in partnership as consultants for six years, had engineered an entire telephone system *de novo* for Constantinople, and were continuously engaged on developments to existing systems in Portugal and elsewhere.

The firm became W. W. Cook and Partners after the 1914–18 War (Gill having joined the International Standard Co.) and carried on extensive practice until Cook retired in 1929.

Cook was loved and highly respected by his contemporaries. His quiet, deep voice, usually serious but often with a chuckle and invariably kindly, revealed both the nature and the character of a gentleman. He was something of a wizard at bridge, which suited his mathematical mind, and he played a good game of golf. His greatest hobby, however, was gardening; to this he gave full rein at his beautiful home at Rusper until the untimely death of his wife, and it remained his chief interest for many more years. He is survived by the elder of his two daughters.

He joined The Institution as an Associate in 1891 and was elected an Associate Member in 1899 and a Member in 1907. He served as a Member of Council from 1909 to 1912. H. K.

PERCIVAL KINGSLEY DAVIS

On the 16th January 1961 Percival Kingsley Davis gave his daughter in matrimony, but on the 17th he had passed, without warning, from this physical world. A very likeable man, tall, and thorough in his presentation of a case, he was witness at several inquiries into the route of transmission lines.

He was born on the 1st April 1898 and received his electrical engineering education at Faraday House, having attended Birmingham Secondary Technical School and Hereford Cathedral School and served with the Royal Engineers during the 1914–18 War.

In 1925 he joined British Insulated Cables, Prescot. When cables from the new Ribble power station to Blackburn were being laid, he turned up in his home-made motor-car—quite typical of his type. In 1928 he joined G. V. Twiss and Partners, Westminster, and, after two years' experience, obtained an appointment with Merz and McLellan, Westminster, as assistant engineer.

From the work on the national Grid, he transferred to the Electricity Board for Northern Ireland in 1932. In 1936 he was appointed superintendent for the Outside Department of the Northmet Power Co., being responsible for the transmission design and construction. In 1948, on nationalization, he became senior assistant transmission engineer, and in 1955 transmission engineer for this area of 8000 sq. miles. On the merging of the technical-electrical section with the transmission section in 1958, he was appointed divisional electrical engineer.

He had a keen sense of humour, his hearty laughter was good to hear, and he was interested in inventing gadgets and devices to fulfil some purpose in his home. He had a liking for music, his interest being in the Gilbert and Sullivan operas. He was a reader of good books and enjoyed apt quotations.

On the day before he died he presented to his church council a report on the electrical installation of the church. He and his wife shared a deep sense of responsibility as devout churchpeople. Known as 'P.K.' both in his home and among his friends, he will be greatly missed by his widow, son and daughter and friends.

He joined The Institution as a Student in 1923 and was elected an Associate Member in 1927 and a Member in 1943. He served on the Transmission Section Committee from 1937 to 1940 and from 1944 to 1947. W. N. C. C.

Obituary (continued)

SIR WILLIAM GEORGE TOOP GOODMAN

Sir William George Toop Goodman who died in Adelaide, South Australia, on the 4th February 1961 was in his 89th year. Born at St. Peter's, Kent, he received his early education at St. George's College. He was articled to Square and Newton, electrical and mechanical engineers, but left in 1887 to serve with Maudsley and Co. and with Simpson and Co., London. He then joined his father, who was a consulting engineer, studying part-time at King's College, London, and at Finsbury Technical College.

He held various positions in this country before going to Australia in 1894 to supervise electrical installations at Mt. Lyell, Tasmania, for Brush Electrical Engineering, following which he was appointed electrical and mechanical engineer in the Public Works Department, Sydney, N.S.W. He designed the first hydro-electric project in the southern hemisphere while engineer to Dunedin Corporation, New Zealand. He went to Adelaide in 1907 to become chief engineer and general manager of the Municipal Tramways Trust and inaugurated the electric tramways system to replace horse-drawn trams and later introduced the first trolley-bus to be operated in Australia. He retired in 1950.

His outstanding ability and forceful leadership early led to a demand for his services in many spheres. He was consulted by the New Zealand and several Australian State Governments. In Adelaide he became engaged in a great diversity of activities, serving as chairman of the South Australian Housing Trust for eight years and as a member of the Council of the University of Adelaide for over 40 years. Despite the demands of his many public duties, he interested himself in a number of private companies.

In recognition of his public service he was knighted in 1932 and in 1945 was awarded the Peter Nicol Russell Memorial Medal of the Institution of Engineers, Australia. His hobbies included flying, deep-sea diving and music. He is survived by two sons and four daughters.

He joined The Institution as a Member in 1899. He served on the South Australian Centre Committee from 1937 to 1946. J. N. K.

ROBERT GOURLAY HARVEY

Robert Gourlay Harvey who died on the 19th January 1961 was born on the 2nd January 1880. He was educated at Ayr Academy, Scotland. He served an apprenticeship with his uncle's firm, Claud Hamilton Ltd., Glasgow. He used to say that he had done a song and dance on every stage in Glasgow, as they wired all the theatres. After his apprenticeship and training at the Royal Technical College, Glasgow, he sailed for two years, mostly in the Mediterranean, as an electrical engineer on the yacht *Margarita*, belonging to an American millionaire.

From 1903 he was engaged on power-station work with the British Electric Traction Co., Penarth, and with West Bromwich and Glasgow corporations. He returned to Claud Hamilton for two years, but in 1913 went to Canada and was the first city engineer of the City of Duncan, Vancouver Island. He designed the power station and was in charge of it. He was also water engineer.

After the outbreak of the First World War he returned to Britain and was employed by Herbert Morris Ltd., crane manufacturers, as manager for Ireland and later as manager in Glasgow.

In 1930 he decided to go into business and at first was in partnership with Mr. Thomson in the firm of E. C. Thomson and Harvey, engineers' agents, and was later in sole charge. He travelled all over Scotland and also in Ireland and had an excellent business connection and many friends among the firms he visited.

In later years, ill-health curtailed travelling and many activities, but his strong sense of humour remained in full force, and his interest in painting and fishing. He was always a keen angler and keen to help others get the same pleasure from it as he did. He played in a rugby trial international with two other Harveys, his cousins, in the team. He was one of the founders of the Ayr Rugby Club more than 50 years ago and was their honorary president for many years. He is survived by his widow, a daughter and a son.

He joined The Institution as an Associate Member in 1923 and was elected a Member in 1943. J. H. P. DE V.

WILLIAM GEORGE HEATH

William George Heath who was born in London in 1878 died on the 2nd February 1961. He was educated at Plymouth Public School and apprenticed to W. J. Corse and Co. for five years, studying part-time at Plymouth technical schools.

In 1901 he established the electrical contracting business of W. G. Heath and Co. It can justly be said that he was a pioneer of the electrical industry in the West Country, for among his many activities he erected in Plymouth the first street-lighting installation of carbon-arc lamps, and the first electric motor to be used in the city was installed by his firm.

His company was also instrumental in installing electrical generating plant for the first electricity supplies to many small towns in Devon and Cornwall, at such places as Buckfastleigh, Plympton, Okehampton, Tavistock, Saltash, etc. Later some of these generating stations were taken over by other companies, and those in West Devon were incorporated in the West Devon Electricity Supply Co., of which concern he was a director.

He provided the accommodation for the first wireless broadcasting station, 5PY, in the South West at Plymouth under P. P. Eckersley of the British Broadcasting Co.

He was also a member of the board of several electrical firms in the country, including the Britannia Cable Co. and Western Rediffusion (S.W.) Ltd. At the time of his death he was chairman of W. G. Heath and Co., the company he founded in 1901.

He was a very keen stamp collector and an enthusiastic bird fancier. He is survived by a daughter.

He joined The Institution as an Associate Member in 1913 and was elected a Member in 1926. He served on the Western Centre Committee from 1922 to 1927, being vice-chairman in 1925–26 and chairman in 1926–27, on the Devon and Cornwall Sub-Centre Committee from 1945 to 1947, and on the South-Western Sub-Centre Committee in 1947–48. G. T. F.

WILLIAM THOMAS HODGSON

William Thomas Hodgson who died in February 1960 was born on the 18th November 1872. He was educated at the City of London School and at Finsbury Technical College. After experience with Swinburne and Co., Teddington, Chamberlain and Hookham, Birmingham, and Kynoch Ltd., Witton, he joined London County Council in 1899. He retired as deputy chief of the electrical division in 1937.

His working life, therefore, broadly spanned the first 50 years of electrical engineering, in both supply and utilization and even in measurement. By the Electricity Supply Acts of the 1880s the L.C.C. had been given certain statutory duties with regard to electricity undertakers in London, and as these supplies developed he acquired an almost unique knowledge of the laws relating to supply and of the intricate system that grew up because of those laws. He was also appointed as 'a competent and impartial person' and as an 'electric inspector' under the 1899 Clauses Act and had charge of the 'statutory' meter-testing laboratory that was provided and staffed by the L.C.C. In addition, he played a considerable part in developing the use of electricity in all the various services of the Council and in particular in education and housing.

He had a quick and original mind, was widely read, and was interested in all things. After retirement he moved to Lewes and soon found an outlet for his energy in local affairs. He is survived by two married daughters.

He joined The Institution as a Student in 1892 and was elected an Associate in 1895, an Associate Member in 1899 and a Member in 1912. F. J.

JAN ARTHUR KUYSER

Jan Arthur Kuyser who died on the 2nd March 1961 was born in Holland on the 14th August 1883. He was educated at Maastricht Grammar School, Holland, and received his technical education in Germany. After working in both Germany and Belgium he went to America, where he spent five years on generator design with American Westinghouse, Pittsburgh. In 1914 he joined British Westinghouse, Trafford Park, under J. S. Peck, and remained there for 41 years until he retired in 1955.

During this period he was responsible for the design of turbo-generators, several of which were at the time the most powerful of their kind. Through his work he gained a world-wide reputation, and his skill was recognized everywhere by engineers concerned with the design and operation of turbogenerators. He was responsible for several patented features, such as the Kuyser system of transposed conductors, which are still in use today.

He was universally liked. He was naturally reticent, yet at times could show surprising firmness and in experimentation an astonishing boldness. As an indication of the esteem in which he was held by his immediate colleagues, he was presented with an illuminated address after 40 years' service, which gave him much pleasure. He is survived by his widow, a son and a daughter.

He joined The Institution as a Member in 1916. Two of his papers 'Protective apparatus for turbogenerators' and 'Recent developments in turbogenerators' were published in the *Journal* in 1922 and 1929 respectively, the former being awarded a Paris premium. H. I. W.

GORDON SPENCER MARSTON

Col. Gordon Spencer Marston, D.S.O., M.C., who died in hospital in London on the 22nd January 1961 was co-founder of J. G. Statter and Co., switchgear manufacturers of Amersham, Buckinghamshire.

He was born at Bournemouth on the 7th June 1892 and was educated at Cheltenham Grammar School. He studied part-time at Birmingham Technical Institute while receiving practical training in Birmingham with the Switchgear Co. for three years and with Berry Skinner and Co. for two years. In 1912 he joined Siemens Bros., Stafford, as a technical assistant.

He served with the Royal Engineers in England, France and Germany from 1914 to 1920 and was awarded the Distinguished Service Order and the Military Cross.

In 1920, with the late J. G. Statter, he began the manufacture of electrical switchgear in a hut in the woods at Amersham: he contributed the engineering 'know-how' and Statter looked after the sales. Today J. G. Statter and Co., with its associate Minerva Mouldings, founded in 1944, has three factories in Amersham. In 1956 the company became part of the Lancashire Dynamo Group, and subsequently Marston became chairman and managing director of Lancashire Dynamo Holdings. He held this position until the group was merged with Metal Industries Ltd. early in 1960.

Marston took an active part in local affairs. During the Second World War he commanded the 5th Buckinghamshire Battalion of the Home Guard and was founder-president of the Amersham Rotary Club. He was a member of the Royal Institution, the Institute of Patentees—he took out a number of patents—and the Engineers' Guild.

He was an active worker for the improvement of education, particularly technical education, in South Buckinghamshire, both with the Education Committee and as a governor of institutes.

He loved the land, with which he had long connections, and owned a considerable amount at Chenies which he farmed himself. A wise and generous friend—many of his good deeds are untold—he used this wisdom and generosity to temper his strength as an employer. He is survived by his widow and three married children.

He joined The Institution as a Student in 1913 and was elected an Associate Member in 1916 and a Member in 1930. J. O. K.

ALFRED McDOUGALL

Alfred McDougall, M.B.E., who died on the 27th January 1961 was born on the 10th April 1885. He was educated at Bath Lane Higher Grade School, Newcastle, and was apprenticed to Mansfield Gibson, Newcastle, studying part-time at Armstrong College.

He devoted his whole life to the electrical industry. After early experience with A. Reyrolle, Hebburn, he joined the North Eastern Railway. During the 1914–18 War he served in the Royal Marines, finally being appointed technical adviser to the anti-aircraft defence commander, Northern Command, for which work he was appointed a Member of the Order of the British Empire.

In 1919 he went to India, where he served as chief distribution engineer to Delhi Electric Tramway and Lighting Co. and later as assistant chief engineer to Madras Electrical Supply Corporation.

In 1924 he joined the Anglo-Persian Oil Co. as electrical inspecting engineer in Abadan and a year later was selected for the position of chief electrical engineer (fields and refineries) in Abadan. During his service he was responsible for the electrification schemes at a time when activities were increasing at a very great rate. In 1936, after 12 years, he was transferred to the London office of the company as assistant chief electrical engineer, being responsible for a complete review and rehabilitation of the whole generating and distribution systems in Abadan. The post-war readjustment of the Llandarcy refinery was also his responsibility.

In 1944 he was appointed chief electrical engineer to the British Petroleum Co. and carried this responsibility until he retired in 1948. However, he remained as consultant to the company and the Kuwait Oil Co. until he severed his connection with his profession in 1956.

During the post-war years his long experience of electrical problems concerning the oil industry was of considerable benefit to British Standards committees dealing with flameproof equipment, of which he was an active member. He also represented the British Standards Institution at international meetings on this subject.

He was a very well-known figure in the social life of the Middle East. He was one of the founder-members and for many years secretary of the English Club at Mohammerah, and visitors passing through that area will no doubt recall his genial personality. He is survived by his widow.

He joined The Institution as an Associate Member in 1917 and was elected a Member in 1931. R. C. T.

MAHADEV VAMAN PANTVAIDYA

Mahadev Vaman Pantvaidya, B.SC., who died after a brief illness on the 16th June 1960 was born in Kolhapur, India, on the 5th March 1889. He was educated at Central Hindu College, Benares, and obtained the B.Sc. degree of Allahabad University in 1913. Subsequently he joined the second batch of students in the Indian Institute of Science, Bangalore, in the electrical technology department under the late Dr. Hay, and obtained the certificate in electrical engineering in 1916. He worked for one year as a research scholar in the Institute.

He served with the Bombay Electric Supply and Tramways Co., Bombay, for three years from 1918, with Cambay Electric Supply Co. for two years, and with the Shikarpur Electric Co. as their chief electrical engineer for three years. In 1927 he joined the Victoria Jubilee Technical Institute, Bombay, as deputy head of the electrical engineering department.

On retiring from the Institute, he started working independently as an electrical adviser and consulting engineer. He designed not less than 12 Diesel power stations and used to advise a number of municipal corporations and electricity supply undertakings in different parts of India. He published a number of pamphlets on various problems pertaining to electric supply in the country, and he also delivered popular lectures on this subject. In 1951 he visited electricity projects in all the important countries of Europe. In addition to five Indian languages, he knew French and German.

He was a good football, hockey and tennis player and was very fond of Indian music. He was of a pious and philanthropic disposition and a sound scholar of Sanskrit literature. He is survived by his widow and two sons.

He joined The Institution as an Associate Member in 1924 and was elected a Member in 1952. He served as a member of the Bombay Local Committee from 1954 to 1957. He was also a Member of the Institution of Engineers (India). P. W. D.

HAROLD DALRYMPLE SYMONS

Harold Dalrymple Symons who was born in London on the 6th October 1881 died on the 15th January 1961. He was educated at Owen's School, Islington, and studied part-time at the Northern Polytechnic, London, at Finsbury Technical College, and at the Manchester School of Technology while serving as an electrician with the Telegraph Construction and Maintenance Co. In 1905 he joined British Westinghouse Electric and Manufacturing, where he concentrated on insulation problems, and later visited America to study this aspect of domestic electrical appliance manufacture.

Continuing to specialize in insulation problems, in 1912 he joined the Sterling Varnish Co., Pittsburgh, U.S.A., as European manager. Immediately before the First World War, he and his lifelong friend, the late Percy Good, subsequently President of The Institution, realized the need for British manufacture of insulating materials and jointly started the company that later bore his name.

He took a leading part in the Electrical Research Association and British Standards Institution committees establishing standards for electrical insulation. Keenly interested in industrial welfare, in 1936 he assisted in the general introduction of paid holidays, a policy of his own company since its incorporation in 1919. He continued as chairman of the company until his death, and his major interest was in the technical progress of his industry.

He is survived by his widow, a son and a daughter.

He joined The Institution as a Student in 1900 and was elected an Associate Member in 1908 and a Member in 1912. He served on the Student Section Committee in 1904–05, as vice-chairman of the Manchester Student Section in 1906–07, and on the Manchester Local Section Committee from 1914 to 1916. He was awarded a John Hopkinson premium for a paper written jointly with M. Walker entitled 'The heat paths in electrical machinery', which was published in the *Journal* in 1912. E. J. N.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

ABBOTT, P., and MARSHALL, H. 51

National certificate mathematics—Vol. 2 (second-year course). Revised edition

London: English Universities Press, 1960. pp. xii, 412. 19 × 12·5cm. 9s. 6d.

This volume covers logarithms, quadratic equations, mensuration, progressions, trigonometrical ratios, the binomial theorem, differentiation and maxima and minima. New exercises based on current National Certificate schemes and examinations are introduced in this edition.

AIGRAIN, P. R., and others 539.13

Electronic processes in solids*

New York and London: Massachusetts Institute of Technology and John Wiley, 1960. pp. x, 67. 23·5 × 15·5cm. 32s.

This monograph is a compact view of band theory and an original treatment of transport theory in covalent semiconductors. It is assumed that the reader has the necessary background, including calculus and elementary wave mechanics.

AMERICAN RADIO RELAY LEAGUE INC. 621.39(03)

The A.R.R.L. antenna book. 9th edition

West Hartford: American Radio Relay League Inc., 1960. pp. 320. 24 × 16·5cm. $2.25

Deals with wave propagation and the principles of antennas and transmission lines. Gives practical details and data for constructing antennas suitable for the amateur bands. Reviewed in the December 1960 *Journal*, p. 734.

AMOS, S. W. 621.314.7

Principles of transistor circuits: introduction to the design of amplifiers, receivers and other circuits. **2nd edition***

London: Iliffe. New York: John Rider, 1961. pp. x, 210. 22 × 14cm. 21s.

An introduction to the design of transistorized equipment. It deals with the determination of input resistance, stage gain, optimum load, power output and other practical matters. In this edition, all references to point-contact transistors in r.f. circuits have been replaced by information on drift transistors and their application in pulse amplifiers and v.h.f. receivers. Voltage-reference diodes and controlled rectifiers are other new topics included.

BABIKOV, O. I. 534.321.9

Ultrasonics and its industrial applications*

New York: Consultants Bureau, 1960. pp. vi, 224. 23·5 × 15·5cm. £4

Deals first with the propagation and absorption of ultrasonic oscillations and their generation. Then describes pulse methods for investigating the microstructure of metals and assessing the elastic parameters and pulse methods of physicochemical analysis. Other chapters cover the machining of hard and brittle materials, aluminium soldering and plating, and ultrasonic cleaning.

BENSON, F. A. 621.38(076)

Problems in electronics with solutions. 2nd edition*

London: E. and F. N. Spon, 1961. pp. xvi, 249. 22 × 14cm. £2 2s.

This edition contains 302 problems and their solutions. A number of additional topics normally found in university undergraduate courses have been included. These include mesh and nodal analysis, Laplace transforms, transistor equivalent circuits, transistor amplifiers and oscillators and the use of matrices for network problems.

BERNSTEIN, J. L. 621.397.6

Video tape recording*

New York: John Rider. London: Chapman and Hall, 1960. pp. xi, 268. 23·5 × 15cm. £3 12s.

This is a practical work aimed at the operator rather than the designer. It describes the types of signal and waveform required for recording television programmes on tape, the nature of electronic photography, bandwidth and other problems of recording video signals on tape, colour-correction circuits, synchronizing circuits and control equipment. Reviewed in the April 1961 *Journal*, p. 241.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE 37

The complete scientist: an enquiry into the problem of achieving breadth in the education at school and university of scientists, engineers and other technologists*

London: Oxford University Press, 1961. pp. xxiii, 162. 22 × 14cm. 18s.

This is a report of the Leverhulme Study Group, under the chairmanship of Sir Patrick Linstead, to the British Association. Reviewed in the May 1961 *Journal*, p. 317.

BROOKES, B. C. (*Editor*) 655

Editorial practice in libraries*

London: Aslib, 1961. pp. x, 204. 22 × 14cm. 21s.

This book is intended to help those working in special libraries to design and edit the publications they are often expected to guide through the press. It deals with traditional printing, photographic and office copying processes for short runs, processes, illustrations, lay-out and design, editing a manuscript, and publishing. Each chapter is the work of a specialist, and the result is a concise, clear and useful guide.

BUBE, R. H. 535.215

Photoconductivity of solids

New York and London: John Wiley, 1960. pp. xix, 461. 23·5 × 15·5cm. £5 18s.

This is a comprehensive survey augmented by over 1000 bibliographical references. It discusses electron processes in crystals, photoconductivity processes, the preparation of photoconductors, electrode effects, imperfections, energy bands, scattering, trapping and recombination processes. Reviewed in the November 1960 *Journal*, p. 665.

DANNATT, T. (*Editor*) 621.312

Electricity in building: a supplement to *Architects' Year Book*. **Vol. 9***

London: Paul Elek, 1960. pp. 102. 25 × 19cm. 10s. 6d.

Although consisting of only 100 pages, this practical guide, set in small type, contains a great deal of information. Contributed chapters deal with distribution and control equipment, wiring systems, space-heating and -heaters, lighting (other than for domestic purposes), lifts and house telephone systems.

DIBNER, B. 92(OER)

Oersted and the discovery of electromagnetism*

Norwalk: Burndy Library, 1961. pp. 47. 28 × 22cm. n.p.

This short but interesting account starts with Volta's discovery of a way of producing current electricity and the subsequent efforts of others to repeat his experiments. It dwells briefly on Oersted's boyhood and education, leading to his discovery of electromagnetism. The subsequent work of Ampère and others is mentioned, and so is Faraday's discovery of electromagnetic induction. This little book is handsomely produced and illustrated.

DUMMER, G. W. A., and GRIFFIN, N. 621.385

Electronic equipment reliability*

London: Isaac Pitman, 1960. pp. xi, 274. 22·5 × 14·5cm. £2 5s.

The authors have collected a great amount of data on this important subject and have produced a most useful reference work. Reviewed in the January 1961 *Journal*, p. 43.

HAMMOND, R. 621.039

British nuclear power stations*

London: Macdonald, 1961. pp. vi, 182. 22·5 × 14cm. 25s.

This is an interesting survey of progress to date and the direction of future developments. Calder Hall, Hinkley Point, Berkeley and Hunterston are described. Methods of obtaining increased efficiency are explained, as well as other developments in design, including safety precautions and the factory manufacture of component parts. Electrical control equipment and switchgear, including special equipment for the control and instrumentation of the reactor, are described. Two final chapters discuss research in progress.

HAWKER, J. P. (*Editor*) 621.39(03)

Television engineers' pocket book. 3rd edition*

London: George Newnes, 1960. pp. 272. 17 × 11cm. 12s. 6d.

Contains concise data on cathode-ray tubes, valves, transmitters, transmission standards, receiver circuits including those for colour, transistorized circuits, aerials and interference, and servicing.

HINKEL, K. 621.385.16

Magnetrons*

London: Cleaver-Hume Press, 1961. pp. 93. 23 × 15·5cm. 22s. 6d.

A general description of the magnetron, its operation and characteristics.

IOFFÉ, A. F. 621.315.59

Physics of semiconductors*

London: Infosearch Limited, 1960. pp. xi, 436. 24·5 × 15·5cm. £4 4s.

This is a translation of the original Russian book that was published in 1957. It has been revised and supplemented for the English edition. Chapters deal with solid electrolytes, metals, a general survey of electronic semiconductors, fundamentals of the quantum theory of semiconductors, physical phenomena (properties of the crystal lattice), methods of measuring the basic properties of semiconductors, and semiconductor materials. The 1958 German edition was reviewed in the April 1960 *Journal*, p. 243.

JEFFREYS, A. E. 014 : 043

Michael Faraday: a list of his lectures and published writings*

London: Chapman and Hall, 1960. pp. xxviii, 86. 25·5 × 19cm. £2 2s.

A chronological list of Faraday's lectures and published works, including articles and letters in periodical publications. Reviewed in the February 1961 *Journal*, p. 122.

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 27th April 1961

ELECTIONS: 1st LIST

Graduates

BISHOP, Kenneth William John
BURKE, James Richard, B.E.
EADES, John David, B.SC.TECH.
EDWARDS, Alfred Dennis, B.SC.
EWINS, James Joseph
GIBBONS, Brian William
GOZNA, Clive Frederick, B.A., M.SC., PH.D.
HALL, Patrick Aidan, B.E.
HERBERT, William Lloyd, B.E.
HORNE, David Victor, B.A.
HUGGINS, Brian George, B.SC.
KNILL, George
MANASTYRSKI, Bogdan, B.E.
MURPHY, Robert Henry, B.SC.(ENG.)
O'KELLY, Eanna Patrick, B.E.
PAPAIOANNOU, George Charilaou, B.SC.(ENG.)
PYE, Charles Thomas
RYDER, Charlie
SEARLE, Errol Clive, B.E.
SEYMOUR, David Walter
SHEPPARD, Thomas Anthony, B.SC.(ENG.)
SHUKLA, Suresh Chandra, B.SC.(ENG.)
TREGURTHA, Peter Graham, B.E.
TYLER, Anton Roy
WASON, Cameron Bernard, B.E., M.ENG.SC.
YUN, Oliver, B.SC.

Students

ABID, Ahmad
ASH, John Christopher
ASHTON, Norman
AUTERSON, James
BIRD, John Richard Angliss
BISSOONDATT, Jailal Carl
BONNER, Joseph Theodore
BOULTON, David Joseph
BOYD, Wilson David
BRADFORD, David John
BREARLEY, Harry
BREARLEY, Malcolm
BRETT, Eric George
BURGESS, Arthur
BURT, Brian Raymond
BYARS, Ronald Richard
COLE, Graham Malcolm
COWLEY, John Sydney
DAVIES, Michael John
DAVIES, Victor Edward
DELAFIELD, Ivor Edward
DENT, Christopher Stanley
DESAI, Shashichandra
DIXON, Ronald Gordon
DUTKIEWICZ, Richard Karol, M.SC.(ENG.)
ENGLAND, Roger Bryan
EVANS, John William
FERNEYHOUGH, Brian Alfred
FRANCOMBE, David Courtney
FREEMAN, Michael Richard
HAREL, Joseph Rene Patrick
HARRISON, Neil Ritchie
HERBERT, David William
HILL, John Graham
HO, Pun-Hing
HOLLAND, Alfred David
HOWELL, David Albert George
HUTCHINSON, David
HWA, Chiu-Kit
IRWIN, Ronald Eric
JENNINGS, John Michael
JETHA, Abdulaziz Kassamali
KULKARNI, Kashinath Mangesh, B.SC., B.E.
LAM, Yeung Kew
LANGDOWN, Colin Barry
LEA, Ronald Joseph

Students (continued)

LIM, Khaik Hoe
LO, Archie Chun Fung
MACKAY, Alastair
McMILLAN, Bruce Watson
MALT, Alfred Philip John
MAY, Malcolm
MEREDITH, Geoffrey Clifford Percy
MIAN, Muhammad Zahid
MILNER, Michael David
MURRAY-SMITH, David James
MYERS, Richard Neville
NALLATHAMBY, Rajendran
OAKEY, John Kenneth
OFFER, David John
OWEN, Tristram Kenneth
PHILLIPS, Margaret Gwenllian
PORTEOUS, Neil John
ROGERS, Peter Raymond
SHARP, David Thomas
SINGH, Deonarine Ramnanan
SIVAKUMARAN, Rajaratnam
TILY, Geoffrey John
TOWNSLEY, Leonard Robert
TUCKER, Andrew
TYERS, Peter John
WARD, John Malcolm
WARMINGTON, David Alfred
WHITE, James Barrie
WILKINSON, Derek
WILSON, Alexander Dey
WILSON, Richard Arthur

TRANSFERS 1st LIST

Student to Graduate

ADEBARI, Akinsola
ATHERTON, Derek Percy, B.ENG.
BRANDIE, William, B.SC.(ENG.)
BROWN, Anthony George Farthing, B.SC.
EL-SHARKAWI, Emad, B.SC.
FOK, Tai Loy, B.E.
GHOSH, Kamal Kumar, B.SC.
HOLMES, John Wetherfield Harold, B.SC.(ENG.)
JAMES, Roy Arthur
KAR, Supriya, B.SC.
MACLENNAN, Geoffrey, A.H.-W.C.
MAPLES, Graham Christopher, DIP.TECH.(ENG.)
MILDNER, John Adrian, B.SC.(ENG.
ROBERTS, Christopher John Udal, DIP.TECH.(ENG.)
SHAHEEN, Hazim, D.L.C.
SMITH, David Graham
TAYLOR, Alexander Melville, A.H.-W.C.

ELECTIONS: 2nd LIST

Graduates

DOYLE, John Joseph, B.E.
EVANS, John
HUGHES, Keith, B.SC.

Students

AMERASEKERA, Rajapakse Mudtanselage
HALL, David Charles
MALHOTRA, Raj Kumar

TRANSFERS: 2nd LIST

Student to Graduate

BOOTHMAN, Alan James, B.SC.
MORGAN, Alan Thomas, B.SC.
PATIENCE, Sidney Philip, B.SC.
POWELL, William Hugh, B.SC.(ENG.)

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH MAY 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	930	9722	2	1
£2 to<£5	2382	6580	19	4
under £2	31456	16594	16	9
		£48764	1	2

APPOINTMENTS AND NOMINATIONS

JOINT COMMITTEE ON THE APPLICATIONS OF ELECTRICITY IN AIRCRAFT

ON the nomination of the Air Ministry, the Council have approved the appointment of Wing-Cmdr. R. E. Powell to succeed Wing-Cmdr. I. Roberts on the above committee.

COMMITTEE ON RADIO INTERFERENCE

On the nomination of the Electronic Engineering Association, the Council have approved the appointment of Mr. D. A. Beresford, ASSOCIATE MEMBER, to succeed Mr. A. H. Cooper on the above committee.

B.S.I. ENGINEERING DIVISIONAL COUNCIL

The Council have nominated Sir John Hacking, PAST-PRESIDENT, as their representative on the above council for a further year, and the President, Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C.*, LL.D., B.SC., to succeed Sir Josiah Eccles, C.B.E., D.SC., PAST-PRESIDENT, as another representative on the same council.

SOUTH-EAST NORTHUMBERLAND TECHNICAL COLLEGE—GOVERNING BODY

The Council have nominated Mr. E. C. Rippon, MEMBER, as their representative on the above governing body.

BELFAST COLLEGE OF TECHNOLOGY—BOARD OF GOVERNORS

The Council have nominated Mr. J. R. W. Murland, B.SC.(ENG.), MEMBER, as their representative on the above board.

CITY AND GUILDS OF LONDON INSTITUTE, ADVISORY COMMITTEE ON INSTRUMENT MAINTENANCE

The Council have nominated L. H. S. Golds, MEMBER, as their representative on the above committee.

THE INSTITUTION EXAMINATION

THE dates of the next Institution Examination are: Part I, 9th–11th October; Part II, 5th–6th October; and Part III, 27th November–1st December 1961. The closing date for the receipt of entries for Parts I and II is the 15th August (home entries) and for Part III the 15th September 1961 (home entries).

The Board of Examiners is as follows:

C. T. Baldwin, M.A., MEMBER
Prof. F. Brailsford, PH.D., B.SC.(ENG.), MEMBER
W. J. Bray, M.SC.(ENG.), MEMBER
J. Brown, M.A., PH.D., D.SC.(ENG.), ASSOCIATE MEMBER
R. Cheesewright, B.E.
H. M. Clarke, T.D., M.SC., MEMBER
A. Draper, M.B.E., B.SC.(ENG.), MEMBER
W. Fraser, B.SC.(ENG.), MEMBER
G. F. FREEMAN, M.SC.(ENG.), MEMBER
Prof. M. R. Gavin, M.B.E., M.A., D.SC., MEMBER
W. J. Gibbs, D.SC., MEMBER
A. W. Gillies, B.SC., PH.D.
Prof. J. Greig, M.SC., PH.D., MEMBER
J. G. Henderson, B.SC., ASSOCIATE MEMBER
H. C. Mann, B.SC.(ENG.), MEMBER
W. D. Oliphant, B.SC., F.R.S.E., MEMBER
Prof. J. G. Parton, PH.D., B.SC., MEMBER
Prof. M. G. Say, M.SC., PH.D., F.R.S.E., MEMBER
P. F. Soper, PH.D.(ENG.), B.SC.(ENG.), MEMBER
E. O. Taylor, B.SC., MEMBER
Prof. D. G. Tucker, D.SC., PH.D., MEMBER
P. Vigoureux, D.SC.(ENG.), ASSOCIATE MEMBER
J. W. T. Walsh, O.B.E., D.SC., M.A., MEMBER
Prof. Emrys Williams, B.ENG., PH.D., MEMBER
D. A. Wrangham, M.SC.

EDUCATION DISCUSSION FORUM

IT is hoped that members who are engaged in the education and training of electrical engineers, and those who are interested in these matters, will seek registration as members of the Education Discussion Forum by completing the application form enclosed with this issue of the *Journal*. They will then receive notice of the meetings of the Education Discussion Circles in London and the local Centres and of other events of an educational nature. No additional subscription is payable in respect of membership of the Forum.

THE INSTITUTION STAFF: EDITORIAL VACANCY

THERE is a vacancy for an Editorial Assistant for work on the *Journal* of The Institution. The qualifications required are an engineering or science degree and some engineering experience. Journalistic knowledge is desirable, but those with literary ability would be considered. Applicants should be about 30

years of age. The salary would depend on qualifications and experience. Entry to a superannuation scheme would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, London W.C.2, giving full particulars of their education, training and experience.

RETIRED MEMBERS AND THOSE OF LONG STANDING

MEMBERS are reminded of a rule that has been in existence for some years, which enables Corporate members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions, or at a reduced subscription, depending on their length of membership. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is set out below:

Any Corporate member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council of The Institution to waive or reduce his future annual subscription, depending on the length of his continuous membership as follows:

25 years	full remission
20–24 years	two-thirds reduction
15–19 years	one-third reduction.

If a retired member of 25 years' standing desires to continue to receive the *Journal*, he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

A further rule provides that as soon as a member of any class completes 50 years of membership he is not required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings*, the arrangement for retired members of 25 years' standing applies.

AUTOMATION—MEN AND MONEY

INFORMATION is now available about the papers to be presented at the conference 'Automation—men and money' to be held at Harrogate from the 27th to 30th June 1961 under the aegis of the British Conference on Automation and Computation, preliminary notices of which appeared on p. 53 of the January 1961 *Journal* and on p. 255 of the April 1961 *Journal*.

The subjects dealt with in the papers include: forecasting requirements for the firm; economic implications of automation; operator selection and training; effect of automation on employment; assessment of profitability; automation and the scale of industrial enterprise; education; physical requirements; speed of automation; social and psychological effects; industrial relations; relation of automation to optimum degree of variety; economic forecasting for industry; and effects on organization and management structure.

Further information may be obtained from Mrs. J. Hodson, Conference Secretary, British Institute of Management, 80 Fetter Lane, London E.C.4.

COMMUNICATIONS

WITHOUT writing a formal paper an author may be able to submit to The Institution a communication that, by dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment, or with limited aspects of a wide subject, would be of considerable interest to the readers of the *Proceedings*. Equally welcome is the brief announcement of a development that later may become the subject of a paper. A suitable length for a communication is 300–3000 words, together with a few illustrations.

The author of a communication may offer it, instead, for publication in the *Journal* as a letter to the Editor, and if it is acceptable and of sufficiently general interest it will be published in this way. As a rule, a letter should not exceed about 300 words, but a maximum of 1000 words can be accommodated in special circumstances.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE 123rd Annual Meeting of the British Association for the Advancement of Science will be held at Norwich from the 30th August to 6th September 1961, under the Presidency of Sir Wilfrid Le Gros Clark, F.R.S. The main scientific programme, arranged by 15 Sections representing the various branches of modern science, will follow an Inaugural Address by the President of the Association.

The meeting is open to all who are interested in the progress of science and in its impact, through its applications, on society as a whole; and a preliminary programme may be obtained from the Association at 18 Adam Street, Adelphi, London W.C.2.

The Presidential Address and a selection of the papers delivered at Norwich will be published in the Association's journal *The Advancement of Science*. The aim of this journal is to review work in progress in the whole field of science and, by a process of selection, to highlight what is significant in that work.

COURSE IN ELECTRICAL MACHINES

A POSTGRADUATE vacation course on the general theory of electrical machines will be held from the 18th to 22nd September 1961 by the Electrical Engineering Department, Imperial College of Science and Technology, University of London. The course will provide an introduction to modern methods of calculating the performance of d.c. and a.c. machines in any conditions of operation. It is intended for engineers working in the manufacturing and supply industries and in the electrical engineering departments of universities and technical colleges.

Further particulars are obtainable from the Registrar, Imperial College, 178 Queen's Gate, London S.W.7.

Announcements to members (continued)

NETWORK THEORY

A RESIDENTIAL symposium on electrical network theory will be held by the Department of Electrical and Control Engineering of the College of Aeronautics, Cranfield, from the 18th to 22nd September 1961. Details are available from S. R. Deards, Department of Electrical and Control Engineering, College of Aeronautics, Cranfield, Bletchley, Bucks.

SPECTROSCOPY

RADIO spectroscopy of solids is the subject of a two-day conference at the Department of Physics, University College of North Wales, Bangor, on the 21st–22nd September 1961. The conference is being organized by The Institute of Physics and The Physical Society and the British Radio Spectroscopy Group. At the conference, Dr. D. Shoenberg will lecture on 'The de Haas–van Alphen effect and the electronic structure of metals'.

Further information is available from the Administration Assistant, The Institute of Physics and The Physical Society, 47 Belgrave Square, London S.W.1.

MAGNETISM AND MAGNETIC MATERIALS

A CONFERENCE on magnetism and magnetic materials will take place from the 13th to 16th November 1961 at the Hotel Westward Ho, Phoenix, Arizona. It will be organized by the American Institute of Physics and the Institute of Radio Engineers.

Further information may be obtained from Mr. P. B. Myers, Motorola Semiconductor Products Division, 5005 East McDowell Road, Phoenix, Arizona, U.S.A.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th March to 16th May 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

BAKER, A. G. (Lagos)
BRADSHAW, H. (Nicosia, Cyprus)
CAMPEY, N. R. (Islington, Ontario)
CANHAM, Jennifer (Ghana)
CATER, C. (Fontanivent, Switzerland)
DAVIES, L. H. (Salisbury, S. Rhodesia)
FERNANDO, E. C. (Colombo)
FURBER, H. D. (Baghdad)
GOYLE, D. N. (Copenhagen)
GRAHAM, M. J. (Pretoria, S. Africa)
GUILD, W. S. M. (Trinidad)
HAFFNER, V. A. (Lagos)
HOTZ, B. R. (Johannesburg)
LAMECH, J. R. (Madras)
LEQUAY, A. L. (Port-of-Spain, Trinidad)
MAUNDER, R. S. (Wellington, New Zealand)
MELLOR, C. H. (Rangoon)
MELVILLE, A. W. (Auckland, New Zealand)
NEWSTEAD, G. H. (Hobart, Tasmania)
PATTERSON, L. S. (Los Angeles)
PETRIE, C. (Nairobi, Kenya)
PETROPOULOS, G. M. (Athens)
SOMERS, D. J. (Auckland, New Zealand)
SPENCER, G. T. (Johannesburg)
SUTHERLAND, D. G. (Pietermaritzburg, S. Africa)
WAKEFIELD, K. S. (Rio de Janeiro)

CATHODIC PROTECTION

ARISING out of the work of the committee that is engaged in the preparation of a British Standard Code of Practice to cover various methods of protecting steel structures that are subject to corrosion in air, water or oil, it has been agreed that work should begin on an electrical code of practice concerned with cathodic protection.

A new drafting committee on which interested persons and bodies have been invited to be represented has been set up to prepare the code, which is to deal with the application of cathodic protection to a variety of metals, including buried and immersed structures and ships. The secretariat is being provided by The Institution.

NUCLEAR RESEARCH GRANT TO OXFORD UNIVERSITY

AT a Press conference held at Oxford University on the 31st May 1961, the text of three decrees relating to a grant by the Department of Scientific and Industrial Research for work on nuclear physics was announced and discussed.

The first decree allocates the southern part of the Keble Road Triangle for the erection of buildings devoted to physics; the second accepts a £750000 grant from the D.S.I.R. for work on nuclear physics, to be carried out under the direction of Prof. D. H. Wilkinson in the Keble Road Triangle buildings; and the third accepts a grant of £75000 from the University Grants Committee towards the cost of the first stage of the work. The group of buildings is to be built in four stages over a period of ten years.

The D.S.I.R. grant is the largest single grant ever made by the Department; it will provide for a particle accelerator of novel design for a long-term programme of research on nuclear structure. Covered by the grant are a horizontal tandem 12 MeV Van de Graaff electrostatic generator, a vertical 8–10 MeV Van de Graaff electrostatic generator, and buildings to house the machines.

IMPROVED OUTPUTS AT NUCLEAR POWER STATIONS

AN increase in electric power output over design figures of more than 25% will soon be achieved at the Calder Hall and Chapelcross nuclear power stations of the United Kingdom Atomic Energy Authority. It has been made possible by a considerably improved heat output from the reactors following comparatively slight modifications, but at no extra fuel cost, and by turbine reblading which is still in progress.

Originally each of the four Calder Hall reactors was designed to give a heat output of 180 MW, from which it was hoped to generate up to 21 MW (electrical) on each of the two turbo-alternator sets per reactor. Design changes enabled the last three of the four Chapelcross reactors to reach a marginally better heat output.

So far, two turbines at Chapelcross and one at Calder Hall have come on load after reblading. The rebladed turbines are generating up to 27 MW (electrical), an increase of 6 MW (or over 28%) on the original expectation.

NEW B.B.C. STUDIO

THE third studio, Studio 2, at the British Broadcasting Corporation's new London Television Centre was brought into service recently. One more studio is due to become operational this year, and it will be followed later by three others which are structurally complete but have yet to be equipped.

Studio 2 is a general-purpose studio that can be used for schools programmes, talks, discussions or any of the smaller, more intimate types of show that do not fully utilize the facilities provided by the larger studios. It is 33 ft high and has a floor area of 3500 ft^2—slightly less than half that of Studios 3 and 4, which are already in use. It is equipped with cameras using 4½ in. image-orthicon tubes.

BULLETIN OF THE SECTIONS

ELECTRONICS AND COMMUNICATIONS

CODING THEORY AND ITS APPLICATIONS

Coding theory is not the easiest of subjects to present in a manner that will hold the interest of non-specialists. In fact, when Dr. J. E. Meggitt delivered his lecture 'Coding theory and its applications' at Savoy Place on the 22nd February 1961, there were a number of specialists present, but there is no doubt that the many non-specialists found the subject most intriguing. An article by Dr. Meggitt, 'Error correction in digital data-transmission systems', will appear shortly in the *Journal*.

Dr. Meggitt was concerned principally with the problem of transmitting digital information over data links which, in the interest of economy, might be telephone lines. An interesting example he gave was the air-travel booking scheme in which details of all reservations made throughout a country were transmitted in digital code to a central store and processed so that up-to-the-minute information on any flight might be obtained instantly by dialling the central store.

Information, detection and correction

Clearly, with such systems errors had to be avoided, and he dealt with a particular class of code that might be used in an ingenious manner to detect errors and even correct them. Errors arose in transmission owing to interference, and the particular form of code described by Dr. Meggitt had been designed to deal with bursts of impulsive noise which might cause, for example, single or double errors in individual 'word' groups for a short time.

To explain the method in its simplest terms, he described a binary code employing groups of seven digits of which four were used for information and three for error detection and correction. Excluding the case of 'all zeros', the three error-detecting digits could be arranged in seven different ways and therefore could locate a single error in any one of the seven digits. The way in which a basically simple 'shift-register' was used to relate the sequence of the error-detecting digits to the 'information' digits was most ingenious. It was indeed remarkable how a similar device at the receiving point could be used to locate and correct the error. Dr. Meggitt described more sophisticated arrangements which gave greater protection at the cost of increased complexity.

The opener of the lively discussion said that the noise on Post Office lines was usually low and the main difficulty was interruptions. Error detection with repeats might be the best solution. Another contributor thought that this was an elegant solution of the wrong problem because 'burst'-type interference did not normally occur. He felt that a trial-and-error approach might do better than mathematics. This view was not shared by another speaker, who thought that a seven-digit code with continuous error detection was probably the best that could be done.

The discussion touched on the merits of systems that counted their errors, self-adaptive systems that matched the code to the channel, and other approaches. There was no sign of its slackening when time ran out.

In closing the proceedings, the Chairman—Mr. T. B. D. Terroni—aptly expressed the appreciation of all present for a most interesting lecture. G. G. G.

MEASUREMENT AND CONTROL, SUPPLY, AND UTILIZATION

HIGH-VOLTAGE MEASUREMENT WITH SPHERE-GAPS

A joint meeting of the Measurement and Control, Supply, and Utilization Sections was held at Savoy Place on the 21st February 1961 with Mr. C. G. Garton in the Chair.

Dr. E. Kuffel delivered a lecture on 'Sphere-gaps', his lecture being supported by four papers, which are reviewed on p. 372: 'The direct-voltage calibration of air-gaps in a uniform field and between spheres up to 25cm in diameter' by E. Kuffel; 'Influence of humidity on the breakdown voltage of sphere-gaps and uniform-field gaps' by E. Kuffel; 'The influence of nearby earthed objects and of the polarity of the voltage on the direct-voltage breakdown of horizontal sphere-gaps' by E. Kuffel and A. S. Husbands; and 'The effect of irradiation on the breakdown voltage of sphere-gaps in air under direct and alternating voltages' by E. Kuffel.

Sphere-gaps are commonly used for the measurement of high voltages, and British Standard 358 gives calibration

tables that have a stated accuracy between ±3 and ±5%. Discrepancies in such measurements are common, and Dr. Kuffel described a series of experiments carried out to assess the effects of the more important variables.

The work has shown that humidity changes, and the proximity of earthed objects, can cause substantial changes in the breakdown voltage of sphere-gaps. He showed that discrepancies between his own calibrations and recent International Electrotechnical Commission figures were primarily due to the effects considered. As a result of this work, a series of recommendations have been prepared for standard test conditions, which should lead to an improvement in accuracy and reproducibility.

Sphere-gaps are an unconscionable time dying

Mr. F. S. Edwards, opening the discussion, mentioned that he had taken part in drawing up the new B.S. 358 and had therefore some personal interest in finding out whether Dr. Kuffel's work cast doubt on this Standard. The worst error seemed to be due to humidity variations, but in his own laboratories the range of variation would cause an error not exceeding 1%. The new B.S. 358 tables were obtained by taking the mean of the previous I.E.C. and American calibrations; this might not be scientific but it gave results which were reasonably correct. He stated that uncertainties in sphere-gap measurements had led many people to express the opinion that gaps were on their way out but, like Charles II, they were an unconscionable time dying, and this new work had given them a new lease of life.

Dr. P. R. Howard described a huge humidity chamber, 70 × 50 × 50ft, that had been constructed at the National Physical Laboratory for investigations on the humidity effects on sphere-gaps, rod-gaps and insulators. Comparison of his results with those of Dr. Kuffel showed some discrepancies that were attributed to differences in test conditions; but the work was still in its early stages.

Problems of the user

Mr. J. D. Endacott stressed the problems of the user of sphere-gaps. They required a large amount of expensive space, and it was very difficult to satisfy an inspecting engineer as to the accuracy of the results. The over-all variation of 6% given in B.S. 358 might seem small, but at voltages in the region of 200kV it was substantial and of economic importance in equipment design. He commented on the difficulty of comparing the work of different investigators because of differing test conditions and pleaded for a co-ordinating committee. Dr. Kuffel supported this plea.

A large number of other speakers dealt with differing aspects of the work and were answered in detail by the authors of the papers. Alternative devices to the sphere-gap were discussed, but Mr. Husbands stated that the sphere-gap was the simplest and cheapest device.

Dr. H. G. Taylor, moving a vote of thanks, commented on the success of the technique of presenting papers with a lecture. He congratulated Dr. Kuffel on the excellence and clarity of his lecture presentation and expressed the view that the work carried out by Dr. Kuffel and Mr. Husbands might lead to a reduction of several per cent. in the margin of error with sphere-gaps. F. C. W.

UTILIZATION

OVERHEAD ELECTRIC-RAILWAY-TRACTION EQUIPMENT

An indication of the special and varied problems that have had to be faced and studied in detail in connection with the incorporation of 25kV a.c. overhead equipment in the traction system now being installed in the electrification of British Railways was given at Savoy Place on the 16th March 1961, when a paper 'A dynamic model for studying the behaviour of the overhead equipment used in electric-railway traction' was presented by Messrs. D. S. Farr, H. C. Hall and Dr. A. L. Williams. Mr. J. M. Ferguson was in the Chair. A short review of this paper appears on p. 374.

Description of model

The authors pointed out that the overhead design of the contact wire and its supporting equipment was of great importance in relation to the problem of current collection at high service speeds, which might now reach 100m.p.h. Because of the great difficulty of carrying out experiments on a railway track in commercial service and the extreme cost that would be involved in constructing and maintaining a special test section of sufficient length, it had been necessary to design and construct a dynamically equivalent laboratory-scale model in order to investigate the effects of variations in design features.

The paper gave a detailed description of the model and of the work so far and intended to be carried out on it, together with the results obtained. This was illustrated by a number of interesting slides, those showing the track lay-out in operation, it must be confessed, raising nostalgic memories of one's own boyhood model-railway days and, no doubt, evoking similar thoughts among others present at the meeting, as most engineers usually retain this fascination with 'trains' throughout their lives.

The discussion, opened by Mr. J. A. Broughall, who referred to the relevance of the authors' work with respect to the particular electrification schemes for which he was responsible, was somewhat brief. This certainly did not reflect a lack of interest among those present but was doubtless due to the rather specialized character of the subject. R. H. R.

GRADUATE AND STUDENT PAPERS

At a meeting at Savoy Place on the 20th April 1961, three short papers were, in accordance with the established annual custom, presented by junior members. It took the form of a Joint Meeting of the Section with the London Graduate and Student Section.

In introducing the authors of the papers, the Chairman, Mr. J. M. Ferguson, called attention to the comparative lack of contributors to the discussion at previous meetings of this character, despite the excellence of the papers presented.

The first paper 'Aluminium in electrical engineering' was by Mr. P. J. H. Rata, who obviously was somewhat startled and nonplussed by a stentorian voice that greeted his opening sentence with the comment 'The laws of nature are inexorable'. This exception to the usual decorum associated with the Section's meetings was apparently due to the momentary accidental inclusion of the loudspeaker in the circuit of the public-address system of a meeting that was being held in another part of the building.

He was followed by Messrs. A. D. Swanston and B. W. Towell, who took for their subject 'Diesel railway locomotives'. The final paper 'Automatic programming for hot reversing mills' was presented by Mr. T. E. S. Rickard.

Intimate knowledge

Each paper was of a high order of merit, and the authors clearly demonstrated an intimate knowledge of their respective subjects, not only in the manner of their presentation but also in the very able and effective way they replied to the interesting discussions that ensued. As each of these had to be curtailed through lack of time, it was evident that the Chairman's earlier remarks on the lack of speakers had borne fruit.

A well deserved vote of thanks, which was accorded to the authors by Mr. A. Porter, Chairman of the London Graduate and Student Section, brought to an end a very interesting and instructive evening. R. H. R.

SUPPLY

MAGNETOHYDRODYNAMIC GENERATION OF ELECTRICITY DISCUSSED

The growing interest in the possibility of directly generating electric power by causing hot gases to interact with magnetic fields, a subject mentioned editorially and in an article by Dr. D. J. Harris in the February 1961 *Journal*, p. 84, was evidenced by the large attendance at the discussion on 'Magnetohydrodynamic generation of electricity' at Savoy Place on the 15th March 1961.

The discussion was opened by Dr. D. J. Harris of Sheffield University and Dr. P. L. Davies. They were followed by a lively presentation of points of view, few of which were concordant.

Feasibility of m.h.d. generation

Prof. M. W. Thring said that there was no doubt that m.h.d. generation was feasible; the question was what efficiency could be obtained. The working gas was subjected to conflicting requirements as an electrical conductor and as a source of energy. These functions might be separable in pulsed systems; he proposed the investigation of striated gases, of polyphase generators and of bouncing shock-waves. Dr. I. Esterman mentioned the interest in m.h.d. generation in the United States and stated his own concern with the possible application of m.h.d. generation to nuclear energy.

Accounts of experimental work were given in only two contributions. One, from Mr. J. S. T. Looms, described an investigation of conductivity in an argon plasma-jet using cooled probes. Mr. Looms showed a high-speed film that strikingly illustrated the rapid and complex variations in both the shape and the intensity of the jet. The other, from Dr. H. J. Pain, was concerned with the use of shock-heated gas to produce a pulse of m.h.d. power. About 0·3 MW had been obtained, but only for 100 μs.

Microscopic or macroscopic

Mr. R. G. Voysey said that the microscopic behaviour of m.h.d. generation systems required investigation and particularly such phenomena as the fluctuations described by Mr. Looms, the cause of which might lie in cavity oscillations. Mr. P. D. Dunn gave a reminder of what was involved in attempting to increase the electrical conductivity of non-thermal ionization—'Ions are expensive things'.

Mr. D. T. Swift-Hook thought that too cautious a view was being taken. Kilowatts of m.h.d. power had been obtained already. Microscopic processes were not necessarily of interest; an ordinary alternator worked whether or not one understood conduction in metals. Practical problems were more important, such as wall-friction, a vortex system for overcoming which had been described as long ago as 1918.

Mr. A. M. Cassie derived some mathematical expressions from which he deduced that axial electric fields would be expected in a m.h.d. generator that would affect the interaction between charged particles and uncharged gas molecules. Dr. P. A. Lindsay said that the instabilities reported by Mr. Looms would come as no surprise to those who had worked with crossed-field devices, which were notoriously noisy.

Mr. J. F. Barnes described some analyses of the possible efficiencies obtainable from jets with electrodeless extraction and radial magnetic fields. Over-all efficiencies as high as 60% should be possible.

In view of the length of this discussion, the opening speakers could reply only briefly. Dr. Harris said that much more time, say 10 years, would be required for large-scale practical development. Dr. Davies, on the other hand, made a plea for more money.

Closing the meeting, the Chairman, Mr. J. E. L. Robinson, thanked the openers and the speakers for providing a most stimulating and interesting discussion. J. S. F.

FIELDS OF MACHINE END-WINDINGS

At a meeting at Savoy Place on the 12th April 1961, under the Chairmanship of Mr. J. E. L. Robinson, two papers were presented. The first paper 'Calculation of the magnetic field of rotating machines. Part 2—The field of turbogenerator end-windings' was by Messrs. D. S. Ashworth and P. Hammond, and the second 'The magnetic field of the end-windings of turbogenerators' was by Mr. P. J. Lawrenson. A review of the two papers appears on p. 375.

Mr. Hammond introduced the first paper and paid a tribute to the courage and faith of design engineers. The conventional way of treating magnetic problems was worthy of re-examination. The paper resolved the field associated with the end-windings into axial, circumferential and radial components.

Mr. Lawrenson presented the second paper. Messrs. Hammond and Ashworth in their paper had concentrated on the stator and rotor windings, while his paper dealt only with the stator windings and harmonics. The analysis concentrated on breaking the stator windings down into sectional filaments and analysing a single coil and using distribution factors thereafter. The results obtained by the methods in the papers were in fairly good agreement. He made some observations on the use of screens to reduce losses in the end-plates and showed a suggestion for a novel type of screen.

Field problem

The discussion was opened by Mr. V. J. Vickers, who regretted that no reference had been made to the material of the retaining rings. He showed a slide illustrating the difference in losses between the two types of ring, which, however, was criticized by later speakers. He pointed out that the effect of the shaft could be appreciable and asked whether the method could be used for concentric windings, as used in some types of induction motor.

Mr. F. R. L. Creek remarked that, in general, stray load losses were of more interest than end-winding inductance. End-plate heating might prove to be a limiting factor with increased conductor-current loading. Flux shielding had been disappointing so far as loss was concerned, but it served to reduce temperatures; and while it was possible that diverters might be helpful in one respect, they might increase the end leakage and therefore the loss in the winding.

Mr. C. J. Carpenter entered a plea for the treatment of the problem as a field problem. The concept of the magnetic circuit had been overdone in the past. A rectilinear analogue would enable a better appreciation to be made of end-winding problems when considering the field at the end-plate. Mr. V. Easton suggested that additional data for a machine running on steady short-circuit would be of value.

Flux mapping

Mr. A. Hunt felt that neglect of the magnetic materials in the problem had led to undue emphasis on the radial and circumferential components of the field, and that allowance must be made for this factor. In future designs where the circumferential connections to the stator winding might carry up to 12kA, the fields associated with these connections might well have an appreciable effect.

Mr. D. C. McDonald stressed that appreciable eddy-current losses could occur in the strands of the end-windings, owing to local flux distribution. Further study was desirable. He asked whether the analyses applied to fields linked with the end-winding region. Mr. P. Richardson said that flux mapping was a useful method. He asked whether the authors had found any substantial differences between their calculated figures and the results of flux-mapping work published previously.

Mr. D. G. Taylor remarked that the subject of the papers was of great interest to those concerned with the analysis of machine performance as well as to designers, but further refinements would be necessary.

Mr. K. C. Parton referred to the use of computers in the evaluation of the figures quoted and pointed out that the programme for such work became quite cumbersome; he was surprised to see that the second paper was alleged to be more accurate than the first—this was not borne out by the plotted results.

Mr. A. B. J. Reece stated that the methods of Smith and Honsinger, referred to in the papers, showed much promise and were capable of great development. Mr. Lawrenson's assumptions of boundary conditions differed on the slotted portions and on the end solid portion of the end-plate. The complicated boundaries favoured analogue methods.

Authors' reply

Mr. Ashworth, replying first to the discussion, emphasized that the difference between the results obtained in their paper and that of Mr. Lawrenson was less than 2%. Mr. Lawrenson, replying to the discussion on the second paper, said that the problem was, in effect, to represent the boundaries accurately. The method of images had been referred to as early as 1898 in a paper by G. F. C. Searle. Mr. Lawrenson spoke of the difficulties of drawing diagrams of three-dimensional fields and mentioned comparisons between analogue computers and scale models; he was not sure that the scale model was a satisfactory solution, owing to the possibility of the existence of a size factor.

The Chairman, in closing the meeting, expressed appreciation of the efforts of the authors and also to those who had taken part in the discussion. W. J. C.

LONDON REPORT

JOINT MEETING

TRAINING FOR THE AIRCRAFT INDUSTRY OF 'ELECTRICAL' AND 'ELECTRONIC' ENGINEERS

SIR Willis Jackson took the Chair at the second meeting organized by the Joint Committee of the Royal Aeronautical Society and The Institution. This was held in the new lecture theatre of the Society at 4 Hamilton Place, London, on the 1st March 1961 and took the form of a discussion on 'The training of "electrical" and "electronic" engineers for the aircraft industry', most ably introduced by Mr. G. S. Bosworth.

The discussion showed the wide interpretation which could be placed on the word 'engineer'. Mr. Bosworth mentioned, as broad groups, research, development, design and application; Wing-Cmdr. W. C. Vaughan referred to the R.A.F. programmes of training of officers having or destined to have university degrees, technical diplomas and a qualification roughly equivalent to the Higher National Certificate; while Mr. F. G. T. Hellings described in detail the apprentice and subsequent training by British European Airways to the standard of the A (radio) licence and X (electrical) licence for maintenance, with specialized training in systems and equipment in use or shortly to be introduced.

The feature common to all these speakers was a strong preference for sandwich courses. Mr. Bosworth added that the carefully prepared brochures of The Institution, 'The training of graduates' and 'The education and training of student apprentices in electrical engineering', seemed to be directly applicable in the aviation field, and Mr. Hellings referred to the similarity of B.E.A.'s methods to the recommendations of The Institution.

Importance of broad education

Both Mr. Bosworth and Mr. J. R. Du Parcq emphasized the importance of mathematics and of breadth of education as opposed to attempts to master the details of narrow specialization. Other speakers stressed this same point, urged the need for strength in physics and the ability to synthesize, and remarked on the value of training in organization. Group-Capt. J. H. Stephens supported this view but called attention to the difficulty of covering the breadth of these fields and suggested further specialized training at about 30.

Mr. W. H. McKinley agreed there was a need for ability to synthesize correctly because of the short time-scale for equipment development and added the need for training in initiative and the inculcation of enthusiasm. People with an aviation background should be included in electrical design teams, and trainees should be given experience on flight trials and installation work. University air squadrons had been of great help.

Mr. Du Parcq also deplored the inferiority felt by and for production engineering. An example of the former was a man who had left school at 15, completed an apprenticeship, become a production engineer at 25 or 26, and obtained a scholarship to a university, as a result of which he hoped to get out of production engineering into design. The other example given was from a confidential report on a man who had taken an honours course but obtained only a pass degree and 'should therefore be suitable as a production engineer'.

Missing glamour

Mr. K. R. Stephenson complained of the difficulty of interesting bright youngsters in what appeared to be the mundane activity of designing the application of electrical equipment in aircraft, their interest tending towards the more glamorous avenues of aerodynamics or structures on the one hand or the development of electronic equipment on the other. He had good men in the 35–45 age group but was very doubtful about their replacement in, say, 20 years' time; he pleaded for an active drive to train young men now. In the maintenance-engineer field Mr. Hellings quoted figures which showed much greater success.

Capt. J. B. Holt followed Mr. Bosworth in concentrating on professional engineers; the Royal Navy considered that electrical engineering in aircraft was very poor and that the aircraft industry did not have its proper quota of chartered electrical engineers. Their training and experience should not all be obtained in the aircraft industry.

Prof. G. A. Whitfield agreed with Capt. Holt and outlined the courses at Cranfield which were aimed at giving aircraft firms good electrical engineers and equipment firms people who knew about aircraft applications and problems. He also got few of the right people, and they tended to transfer to the electronic industry rather than return to aircraft firms, where the work was not interesting and not sufficiently responsible.

We were invited by Mr. E. C. A. Backhaus to remember the dependence of the equipment on the way it was used by

the pilot and aircrew; he advocated some air experience, preferably in the driver's seat, to meet this need and, at the same time, to provide some of the missing glamour.

Mr. A. J. Cope quoted the increase in installed capacity between the Pionair (Dakota) with 3kW and the Vanguard with 300kW. He also opposed specializing too early.

Engineers doing technicians' work

Mr. Bosworth, summarizing, suggested 'more physics and less metaphysics' in basic education and more attention to fundamentals in technical education rather than a broad survey of many technologies.

There was an inadequate supply of electrical engineers generally, and the bias was intentionally towards electronics. Moreover, power engineers thought of megawatts at 50c/s and were not interested in 300kW even at 400c/s. We, who were concerned with this aircraft electrical field, had to 'advertise'. After agreeing briefly with the views already expressed on analysis and synthesis and on the importance of production, Mr. Bosworth stressed again the importance of the organization of people; the inability of engineers to delegate responsibility resulted in a wastage of highly qualified people on technicians' work.

Sir Willis Jackson, in thanking Mr. Bosworth, referred to the increase in annual output of scientists and technologists but asked if we were using this output to the best advantage and whether we could reassure the 'output' on this point. He suggested that possibly we were truly more lacking in well trained technicians than in professional engineers. J. F. L.

ORDINARY MEETING

SUPPLY OF REACTIVE POWER

THE Supply Section paper on 'Technical and economic aspects of the supply of reactive power in England and Wales', given by W. Casson and H. J. Sheppard at Savoy Place on the 6th April 1961, attracted an unusually large audience. Sir Hamish D. MacLaren, the President, was in the Chair, supported by J. E. L. Robinson, the Section Chairman. A review of the paper appears on p. 377.

W. Casson's competent and lucid introduction of the paper cleared up a number of obscurities in the text and helped the audience to grasp the authors' somewhat novel treatment of a complex subject. The main theme was the need for as much pre-planning in the provision and control of the kVAr as for the kW output, and the lengthy discussion that followed bore witness to the interest aroused. It centred on the tariff aspect and was perhaps a little lacking in that element of spontaneous combustion usually associated with any debate among engineers on supply tariffs. Possibly this was owing to the fact that the voice of the man who pays for it in the end—the consumer—was not heard at all!

kW, kVA or kVAr?

Opening the discussion in his usual whimsical vein, J. L. Egginton complimented the authors on producing a paper embracing the whole field from generator to consumers' installation—a breadth of subject all too rare in the general run of Institution papers. A later speaker, S. C. Chu, also pointed out that this was the first full-scale review of the power-factor problem on a national basis presented to The Institution. J. L. Egginton came down in favour of a straight kVA charge, largely on account of its simplicity to the consumer. C. M. Mitchell and other speakers took a rival stand with a preference for a kVAr charge distinct from kW or kVA, generally as advocated by the authors. P. d'E. Stowell beamed in the virtuous knowledge that his Board alone, among the others, had in fact been using such a tariff for the last 12 years.

D. J. Bolton also sided with the supporters of the kVAr charge, but only after some sharp criticism of the economics given in the paper—an authoritative challenge that the authors will, no doubt, treat with respect, along with some similar criticisms by K. C. Parton and other speakers. R. A. Hore added some not-unwelcome colour to the discussion by flatly rejecting the commonly held view that power-factor correction should begin at home—i.e. on the consumers' plant—and spurned any form of incentive in the supply tariffs. F. H. Birch brought the discussion back to a more technical note by emphasizing the growing requirements of the system and the need for reserve reactive capacity as well as reserve kW capacity. He quoted costs of various types and sizes of compensatory equipment.

The reference in the paper to transductors provided an opportunity to E. Friedlander, which he was not slow to grasp, of extolling the flexibility and other virtues of this apparatus, with which he has been so closely associated. However, he was not allowed to have it all his own way, as F. Moores and R. O. M. Powell were equally quick to rise in defence of the more humble and perhaps cheaper capacitor.

Inactivity

F. Byrne, looking at the paper through the eye of the meter expert, recalled an Institution discussion 25 years ago when reactive metering was little more than a dream! He suggested that *in*active would be a more appropriate term than *re*active, but perhaps overlooked the consequence of being referred to as an *in*active-power-meter man!

The delicacy of nomenclature came up again in W. Casson's reply to the discussion, when he had to restrain himself from talking about a synchronous condenser in place of the more correct, but less palatable, synchronous compensator.

H. J. Sheppard wound up with some spirited replies to the critics, to be set out more fully in writing. He made the pertinent point that a simple kVA charge would become increasingly inequitable if the fixed charge in the supply tariff continued to increase.

J. E. L. Robinson moved the vote of thanks with charm and sincerity and echoed the sentiments of many of the audience in saying that, as members of the Supply Section, the two authors had 'done them proud'. D. P. S.

DISTRICT MEETING AT READING

EUROVISION

MR. E. W. Weaver took the chair at the fourth and final meeting of the 1960–61 Session on the 20th March 1961. The talk by Mr. M. J. L. Pulling on 'The development of Eurovision' was based on his Chairman's Address given to the Electronics and Communications Section on the 28th October 1959. An article based on the Address appeared in the February 1960 *Journal*, p. 96.

Mr. Pulling began his talk by referring to the name 'Eurovision', coined by a member of the British Broadcasting Corporation's staff, and described the first B.B.C. television outside broadcasts from Calais to London. These broadcasts took place in August 1950, and it was the first time that a television link had been made across an international boundary. The success of this undertaking led to a series of joint R.T.F.–B.B.C. programmes in July 1952. This project involved conversion from the French line standard of 819 to the British of 405.

Mr. Pulling described the arrangements for the television broadcast of the Coronation of Queen Elizabeth on the 2nd June 1953, which was relayed by a total of 12 transmitters in France, the Netherlands and Western Germany. The broadcast aroused much interest and underlined some of the outstanding problems.

Technical risks involved

Mr. Pulling discussed the June 1954 series of programme interchanges, involving eight national television organizations. These exchanges were a modest success and, although many mistakes were made, much was learned. It was following this series that the European Broadcasting Union took over the responsibility for planning and supervising these interchanges on a routine basis. This resulted in the establishment of a permanent co-ordination centre in Brussels.

In discussing the technical risks involved in setting up television networks, emphasis was placed on the distances covered, the number of separate authorities taking part, the total number of links in tandem, and other factors.

The vision links and their development were next described and their progression from simple low-power portable transmitters and receivers to the more sophisticated centimetric and decimetric equipments of the present time. Other subjects covered included the problems of standards conversion and the question of costs and their impact on the smaller organizations. Mr. Pulling concluded his most interesting talk with a brief reference to the B.B.C. cablefilm technique for sending 16mm film over the transatlantic telephone cable. Possible future links by means of Earth satellites were also touched on.

Mr. Pulling dealt very adequately with questions relating to the amount of recording used by the B.B.C., the difficulty of lining up centimetric-wave dishes, the reception in Germany of British contributions to Eurovision, and a suggestion relating to the use of magnetic recording in connection with line-standards conversion.

R. G. H.

News from the Centres

WESTERN CENTRE

Electricity in aircraft

A JOINT meeting with the Gloucester and Cheltenham Branch of the Royal Aeronautical Society was held at Cheltenham on the 22nd March 1961, when Mr. M. Hancock presented a paper 'New ideas in aircraft electrical systems'. The paper was well received and was followed by a varied and lively discussion.

Two-speed squirrel-cage motors

On the 10th April 1961, Prof. G. H. Rawcliffe delivered an informal lecture on 'Speed-changing induction motors—further developments in pole amplitude modulation'. This lecture was a continuation of the paper in the December 1960 *Proceedings*. In opening, the lecturer paid special tribute to Drs. W. Fong, R. Burbridge, J. Creighton and Mr. A. R. Broadway, who had greatly assisted him in the development of the concept of the speed-changing motor.

It was stated that this was essentially a two-speed motor, but the essence of the design was that the simplicity of a squirrel-cage motor was retained and the motor had only a single winding, with six terminals and six leads on the stator casing.

As there was only one winding, the high leakage reactance associated with two-winding machines was obviated; consequently, for any given frame size, 85% of output at one speed and 70% of output at the other speed could be obtained. Also, the machine efficiency at either speed was approximately equal to the efficiencies obtained on separate machines. Eight machines were exhibited, the speeds ratios varying from 1500 : 350 to 750 : 600r.p.m. These motors were run up to speed, plugged, reversed and speed-changed in a matter of seconds.

Mr. C. W. Minchin opened the discussion by asking whether the presence of harmonics had been considered. He

agreed that such motors would be instrumental in the saving of running costs, particularly in large machines.

The discussion was continued by Messrs. J. F. Wright, T. Baldwin, A. J. Parsons and A. N. D. Kerr, and, in conclusion, Mr. G. Redfern proposed a vote of thanks to the lecturer.

Chairman's Address

At the request of many members 'north of the Channel', the Centre Chairman, Mr. A. C. Thirtle, again presented his paper on 'Public electricity supply—its past and likely future developments' at Cardiff on the 26th April 1961. This subject was of the utmost importance to South Wales in view of the great industrial expansion taking place in that area. E. J. M.

TEES-SIDE SUB-CENTRE

Fylingdales station

THE New Year opened brightly with an excellent attendance at the lecture on the 4th January 1961. 'The Fylingdales ballistic missile early-warning station'—a subject of particular local as well as universal interest—was presented in a fluent manner by Mr. F. Harrison. Mr. W. L. Freebody, of the Royal Radar Establishment at Malvern, showed some very striking slides of similar installations on the American continent.

On the 1st February 1961, it was our pleasure to meet Vice-President Mr. A. H. Mumford, who made the most of the informality afforded by our Conversazione. Very welcome, too, was Mr. D. H. Thomas, the North-Eastern Centre Chairman, who repeated his Inaugural Address 'Developments in technical education during the past 60 years'.

Application of electronics

The 3rd Hunter Memorial Lecture, 'The application of electronics to the electricity supply industry', was presented on the 1st March 1961 by Dr. J. S. Forrest and attracted good support. The paper, and the excellent range of demonstration equipment, brought home the tremendous advances made in the electronics field, and the interest aroused was evident in the lively question period that followed.

The final meeting of the session took place on the 3rd May 1961, when Mr. G. S. Buckingham presented his interpretation of research results obtained in recent years by the British Electrical and Allied Industries Research Association. His paper, 'Short-circuit ratings for mains cables', well received by a large audience, will be of value towards a better understanding of the problems involved in the selection of cables.

Works visit

Saturday, 8th April 1961, was the occasion of our first works visit of the year—to Vickers-Armstrong's naval yard at Walker on Tyne—and, as in 1960, we were pleased to see that members took full advantage of the opportunity of bringing their ladies.

The party of 37, having travelled by coach and car, spent a most rewarding two hours at the shipyard, made the more pleasant by crisp, clear weather. Vickers-Armstrong boast a fine models room, and we spent an enjoyable time there and in the plating shop and loft.

The outstanding attraction was, of course, the 65000 ton *Serenia*, the largest oil tanker yet to be built in Britain, which will ply between the United Kingdom and the Persian Gulf with her complement of about 80.

It was perhaps a little unfortunate that *Serenia* was still two months away from completion, but there were many features aboard compelling the interest of both members and ladies.

Lunch and a free afternoon in Newcastle rounded off a visit that must be counted as one of the Sub-Centre's most successful. N. M.

SHEFFIELD SUB-CENTRE

Annual Dinner-Dance

THE Sub-Centre Annual Dinner-Dance was held at the Royal Victoria Hotel, Sheffield, on Friday, 14th April 1961. Some 310 members and guests heard Mr. F. Seddon make his customary appeal on behalf of the Benevolent Fund. The response was overwhelming, with the record number of 43 raffle prizes helping to raise the record total of £258. We were pleased to see a number of the North Midland Centre notabilities, including the Chairman, Senior Vice-Chairman, Hon. Treasurer and Hon. Secretary, present.

At the Annual Dinner-Dance of the Sheffield Sub-Centre

From left to right: Mrs. and Dr. J. Allison and Mr. and Mrs. E. J. Lilleker

The Annual Dinner-Dance is becoming so popular, and the refusal of applications so embarrassing, that this year's function was slightly overcrowded. Some consideration is

therefore being given to changing the venue for next year or reducing the numbers, with the risk of a further increase in the price of tickets. J. E. L.

SCOTTISH CENTRE

Engineering and civilization

One of the highlights of the North Scotland Sub-Centre's programme for the session was the Graham Clark Lecture 'Engineering and civilization' delivered by Sir Hugh Beaver to a Joint Meeting with The Institutions of Civil and Mechanical Engineers in Dundee on the 3rd February 1961; before delivering the Lecture, Sir Hugh had presented prizes at the Dundee Technical College and the parents were also invited to hear the Lecture.

Successful District Meetings have again been held in the North at Thurso and Inverness, and a Vice-Presidential visit paid to Aberdeen on the 9th December 1961 included a small dinner party at the Caledonian Hotel.

District Meetings have also been held at Kilmarnock and Dumfries by the South-West Scotland Sub-Centre and at Galashiels and Dunfermline by the South-East Scotland Sub-Centre, the meeting at Galashiels, where Mr. J. Griffin spoke on 'A.C. motors and control', attracting a record attendance of 98.

Depreciation

Owing to the illness of Mr. D. Rudd, his paper on 'A general theory of depreciation of engineering plant' was read to the South-East Scotland Sub-Centre in Edinburgh by Mr. J. Mendelson, Past-Chairman of the Sub-Centre; a panel comprising Mr. J. Pardo, Financial Controller of the National Coal Board, Scotland, Mr. A. M. Ferrier, Chief Accountant, North of Scotland Hydro-Electric Board, and Maj. W. E. Bruges, recently of the South of Scotland Electricity Board, had been set up to answer questions raised in the discussion. In spite of the absence of the author, a very lively and instructive discussion ensued. E. O. T.

MERSEY AND NORTH WALES CENTRE

Railway electrification

At the Ordinary Meeting held at the Liverpool Royal Institution on Monday, 6th March 1961, favoured by the visit of Vice-President Mr. C. T. Melling, the proceedings were informal. Two films on railway electrification were shown, the British 'Power to the pantograph' and the French 'Valenciennes–Thionville', and it was noticeable how the difference in design illustrated and contrasted the characteristically national approach.

Annual Dinner-Dance

The Annual Dinner-Dance was held on Friday, 24th March 1961, at Hulme Hall, Port Sunlight, when the Chairman Mr. D. A. Picken, and Mrs. Picken welcomed 275 members and guests to a most enjoyable evening. A dozen prizes were given by members and business friends for the benefit of the Benevolent Fund and were presented to the lucky competitors by Mrs. Picken.

Mersey and North Wales Centre Annual Dinner-Dance

Mr. and Mrs. D. A. Picken (at left) receive Mr. R. N. Pegg and his daughter, Mrs. Herbert Davies

The duties of Master of Ceremonies were ably performed by Mr. W. J. C. Kennerley.

Annual General Meeting

At the Annual General Meeting on Monday, 10th April 1961, Mr. R. N. Pegg was elected Chairman and Mr. J. A. Mason elected Vice-Chairman for the forthcoming session. Mr. W. Parry announced his resignation as Hon. Treasurer, an office he had so diligently filled since 1947. Even then he was no newcomer in service to the Centre, having carried the burden of Hon. Secretary for ten years including the period of the war, plus two years as Hon. Assistant Secretary. Mr. S. Towill was elected as successor.

A further change was the resignation of Dr. A. N. Fletcher, who had given valued service as Hon. Assistant Secretary in activities based on Chester.

Following the business of the meeting, Prof. A. M. Meek lectured with many impressive demonstrations on 'The mechanism of lightning'. It was considered convenient that, with the equipment assembled, the lecture might be repeated, and thus the following afternoon Prof. Meek entertained and instructed an audience of some 400 senior scholars.

District Meetings

District Meetings in Warrington and Wrexham were well attended, and Mr. T. A. P. Colledge 'got off the ground' on the 21st April 1961 to deliver a lecture on 'Interplanetary travel' to a District Meeting held at Douglas, Isle of Man. E. W. A.

News from abroad

MIDDLE EAST GROUP OF PROFESSIONAL ENGINEERS

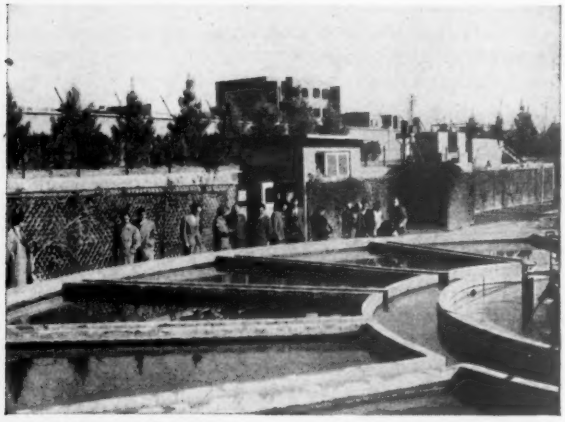
Tehran water supply

On the 26th–27th January 1961, the Group held a successful meeting in Tehran. Mr. Dilmagani, of the Tehran Water Board, spoke on the Tehran water-supply system—past, present and future—to an audience at the Engineering Department of Tehran University.

In his paper, Mr. Dilmagani dealt principally with the present water-supply system, which provides some 117 million m^3 of water per year to Tehran and Greater Tehran, with 1¼ million inhabitants. The raw water is coagulated, sedimented, filtered, sterilized and treated, and the plant ancillaries cover wash-water recovery, sludge disposal, pumping and generating, together with chemical manufacture and the supply of chlorine and ferric chloride.

This address was both interesting and enlightening, and it was surprising to hear that the existing water supplies will have to be quadrupled in 15 years owing to the rapid growth of Tehran, which is forecast to grow in that period to 4 million inhabitants.

After the meeting, members enjoyed cocktails and an excellent dinner provided by the National Iranian Oil Company.



At Tehran Water Works

Friday was a delightful day after the snow on the previous evening, and members visited Tehran Water Works to break the ice there. This visit served to illustrate the paper given on the previous evening. The Tehran Water Board gave their visitors an excellent luncheon at their club.

Kuwait power station

The Kuwait meeting of the Group was held on Thursday and Friday, 23rd and 24th February 1961.

At this meeting, a paper was presented on the 30 MW extension currently being constructed to the Kuwait power station. The paper showed the constructional features of the power station by means of an excellent series of slides which illustrated, in colour photography, the various stages in the construction of the new extension. In the extension there are three boilers, each of 320 000 lb/h evaporative capacity, of the integral furnace type, passing steam at 600 lb/in^2 and 850°F to three 30 MW impulse-type condensing turbo-alternators generating at 11 kV.

After the meeting, some 90 members and guests enjoyed an excellent buffet supper provided by the Kuwait Oil Company. On Friday, about 20 stalwart members toured the extension in a howling *shimal* and were very grateful for the luncheon provided.

BOMBAY BRANCH

Social gathering

At a social gathering for members of the Branch on the 26th March 1961 at Resham Bhavan Hall, Bombay, Prof. M. S. Thacker, Director General of the Council of Scientific and Industrial Research and Secretary of the Ministry of Cultural Affairs, Government of India, who was the guest of honour, called for a reorientation in the pattern of the syllabus for engineering and technological education in India. Modern India needed engineers and technologists who were conversant with the fascinating and fantastic progress being made in the world. The present syllabus could produce only a supervisory and maintenance cadre.

98 members and ladies attended the function, under the Chairmanship of Mr. J. C. Patel.

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